THURSDAY, MARCH 10, 1898.

TWO TEXT-BOOKS OF ELEMENTARY GEOMETRY.

Geometry for Beginners. By G. M. Minchin, M.A., F.R.S. Pp. xii + 102. (Oxford: at the Clarendon Press, 1898.)

Euclid's Elements of Geometry, Books I. and II. Edited for the use of Schools, by Charles Smith, M.A., and Sophie Bryant, D.Sc. Pp. viii + 160. (London: Macmillan and Co., Ltd., 1897.)

THE appearance of these two little books shows that practical teachers have not yet agreed upon the best method of teaching elementary geometry. That this should be so is by no means a matter for regret; in the course of the controversy each party learns something from the criticism of the other; examination papers tend to become less stereotyped, and better adapted to test the student's real knowledge of the subject; while an intelligent teacher is more and more able to assert his right of freedom in giving geometrical instruction according to the method which, after a fair trial, he finds to be most efficient.

Prof. Minchin's book is a very favourable specimen of the methods of the reforming party. It is really what it professes to be, a book for beginners; it is obviously the result of long experience, and there is no reason to be surprised at the author's statement that the book has been used with boys of eight years with very great success. A very welcome feature, which might be adopted by all writers of introductory text-books, is the description of the graduated scale, the compass, the protractor, and set-squares, and of the way in which they are used. Parallel rulers are also described; it would have been well, in our opinion, to add that, while much may be learnt by handling a pair of parallel rulers, they are of little use for practical purposes, and that, generally speaking, set-squares should be used for drawing parallels. It is probably an oversight that the use of set-squares for drawing perpendiculars has not been explained. We thoroughly agree with Prof. Minchin in the opinion that the careful construction of figures, by means of the proper instruments, should be insisted upon for the sake of training the eye and hand of the pupil; and it may be added, that this exercise invariably helps to maintain a boy's interest in the problem or theorem upon which he happens to be engaged.

The choice of propositions is very judicious; they include the congruence of triangles, the elementary theory of parallels, exclusive of the so-called "axiom," properties of parallelograms, easy theorems about areas, and the theorem of Pythagoras. Besides this there are a few miscellaneous propositions, as, for instance, that the angle in a semicircle is a right angle. Definitions, we are glad to see, are introduced when they are wanted, and not before; and when necessary they are clearly explained and illustrated. The exercises are simple and well-chosen: it would be easy to add to their number and variety, and this would be an advantage to the book.

Of course there are some points which provoke criticism; but in offering any remarks upon them it is necessary to bear in mind the intention of the author; thus, for instance, however much the orthodox may protest, we think it is quite legitimate to define a straight line as the shortest distance between two points; on the other hand, it seems to us that the statement "a point is the smallest dot that can be made or imagined" is distinctly misleading, and that it is quite possible to give a more accurate idea of what is meant. Then again there is no objection, at this stage, to saying that a plane is a perfectly flat surface: but the top of a table, a school-slate, or the surface of water in a basin is a better illustration than a sheet of paper. It would also be a good thing to point out the reverse order of procedure, where a surface appears as the boundary of a solid, a line as that of a surface, and a point as that of a line, or the crossing of two lines. A playing ball painted in different colours makes a good illustration; so does a cube, a ruler, or a piece of india-rubber of the ordinary shape.

In some cases only one figure has been given where there ought to have been two or more: for example, in propositions L, S and T; and in the problem on p. 79 it might be pointed out that R may be on either side of PQ, but that the construction fails if we take PR equal to PO, and try to put R on the same side as O.

In cases where circles are used in the construction of figures, it is properly observed that it is not always necessary to draw the complete circles. We would go a little further than this, and in the later propositions, at any rate, introduce in the figures quite small arcs, such as those made by a practical draughtsman; this might be done, for instance, on pp. 78, 79. As the student is supposed to use a pencil compass, there would be four small arcs to indicate on p. 79.

It would be a great mistake to overload a work of this kind; still it might be thought worth while, and would not be inconsistent with the plan of the book, to give the construction for dividing a line into a given number of equal parts, and that for reducing a rectilineal polygon to a rectangle of equal area. The construction of a regular hexagon and a regular octagon might perhaps be included, either as propositions or examples; and it would be well to add some examples, say, of plotting quadrilateral or pentagonal fields from given data, or of drawing such figures as, for instance, a square with an outward semicircle on each side of it as diameter.

These suggestions are made in the confident hope that there will soon be a demand for another edition of Prof. Minchin's excellent little book. In the hands of a competent teacher it cannot fail to be successful; and it will do much, we hope, to convince the average parent and schoolmaster that geometry is not dull mechanical drudgery, and that its principles and results may be comprehended by means of ordinary common-sense. Its adoption as an introductory course will not hinder, but greatly help, a more rigorous study of the subject afterwards; even the most questionable part of the book, the sham proof (for such it is) of the sum of the angles of a triangle being equal to two right angles, need not be a permanent stumbling-block in the pupil's way.

The edition of Euclid's first two books by Mr. C.

Smith and Mrs. Bryant is of the moderately conservative type, preserving Euclid's order of propositions, but admitting, especially in Book II., some simplifications of construction and proof. It is not easy to see any definite advantages of this edition over others already in the market; and in some respects it is certainly inferior. The figures are poor; not a few awkward for the pupil to draw, *e.g.* those on pp. 76, 100; and some are grossly inaccurate, such as those on pp. 80, 122. Then, considering the authors' evident desire for strict logic and accurate statement, some of their *obiter dicta* are really surprising. Thus we are told that "the *unequal* side of an isosceles triangle is generally called the base"; that I. 44 is "sometimes enunciated in the form, 'Construct a parallelogram equal to a given parallelogram, and having one of its sides of given length'"; and that I. 17 is equivalent to "If a straight line intersects two other straight lines which meet in a point, the two interior angles which it makes with those straight lines are together less than two right angles." Not to mention the fact that the three lines may be concurrent, the interior angles referred to ought to have been specified.

The bad plan is followed of placing all the definitions, axioms, and postulates at the beginning; a wrong definition of *postulate* is given so as to confine it to postulates of construction, and the postulate required for the theory of parallels appears in its time-honoured, but non-Euclidean place as an axiom. The authors are of opinion that axiom 9 ("magnitudes which can be made to coincide are equal") is Euclid's definition of the equality of geometrical magnitudes, and ought to be put first, and then the other axioms 1—7 can be proved by superposition. In this we feel sure they are mistaken. The real meaning of axiom 9 is that magnitudes which can be made to coincide are *equal* in a sense consistent with the term as used in the preceding axioms; thus, for instance, if a figure A can be made to coincide with a figure B, and if another figure C can be made to coincide with B, then A and C can be made to coincide. That Euclid does not imply the congruence of equal magnitudes is obvious from I. 35, &c. It is true that either of the parallelograms in I. 35 may be cut up into pieces which may be fitted together so as to make up the other parallelogram; but this fact does not appear in Euclid's proof, and it is doubtful whether he was aware of it. And it is clear that "equal" cannot mean simply "congruent," because if congruent figures are taken from congruent figures the remainders are not necessarily congruent.

This brings us to the statement (p. 66), "Whenever there is equality of area" of two figures, "one of the figures can theoretically be divided into parts which, when properly fitted together, will coincide with the other figure." If "parts" means "a finite number of parts," we should like to know the proof of this assertion: it cannot be true in any sense except for figures drawn upon surfaces which are applicable to each other. To take a very simple case, can it be verified for three circles whose diameters are the sides of a right-angled triangle?[1]

In the alternative proof of II. 12, no reason whatever is given for the equality of the rectangles AY, AZ, so that the whole difficulty of this method of proof is shirked by means of a "similarly" applied to dissimilars; the same imperfection occurs in the alternative proof of II. 13.

In I. 24, figures to illustrate the different cases ought surely to have been given; and we should have thought that the direct proof, by superposition, of the first case of I. 26 might have been admitted as an alternative.

Twenty-six abbreviations have been adopted; the definite article is expressed or omitted according to some mystical principle which we have been unable to discover; in some cases the construction and proof are kept separate, and duly labelled in Clarendon type accordingly, in others they are mixed up.

We confess that, on the whole, the perusal of this book has had a depressing effect; it is like reading a treatise on apologetics, and finding that it leaves you more inclined to be sceptical than before. The most serious objection made against text-books of the more modern type is that young boys fail to really grip the essential parts of some of the proofs, and thus, though they understand them at the time, reproduce them in an imperfect and slipshod manner. But here we have two editors of the orthodox text-book, brought up themselves, no doubt, in the true Euclidean faith, and with scores of school editions from which to take warning and example who nevertheless are by no means above reproach, in grammar, logic, or precision of statement.

Erroneous methods of teaching elementary geometry are still so prevalent, and teachers are so apt to rely entirely on their text-book, that every treatise, Euclidean or not, which is intended for beginners, should contain a description of simple instruments and their use, and some hints on the proper way of learning the propositions. Before a teacher sets a proposition to be learnt he should, with a class of beginners, go through it with a blackboard explaining every point, and in particular every technical term when it first occurs; he should insist upon the data of the figure, and these only, being first drawn, and the rest put in as the steps of the construction are stated (this should also be done, at first, by the pupil when learning the proposition); and he should, from the outset, avoid using the same letters as those in the book. This, and the early introduction of very simple exercises, will ensure that the pupil uses his brains and not merely his memory; unless this is the case, the study of geometry is about as improving as it would be to learn by heart a page of the London Directory. G. B. M.

[1] Unless the arguments of Réthy (*Math. Ann.* xxxviii.) are unsound, this question must be answered in the negative.

OUR BOOK SHELF.

Whittaker's Mechanical Engineer's Pocket-Book. By Philip R. Björling. Pp. 377 + viii. (London: Whittaker and Co., 1898.)

A GOOD pocket-book is a necessity to the engineer; it supplies him with reference tables and constants for facilitating calculations, and also the experience of other engineers in a condensed and handy form for use. One feature of this work is that a rather larger share than usual is given to hydraulics and hydraulic machinery, and also to mining plant. In the formula on p. 3, for the discharge over weirs, a too small coefficient of discharge (apparently 0·45 only) has been adopted; there is also a misprint in the first line of the second column on p. 7, it should be 8·025. In the formula on p. 55, for friction of the leather collars of rams, it is not stated

in what units the answer is obtained; presumably it is in pounds. The one section which is very disappointing is that devoted to gas engines; only three pages are given to them, and one of these is filled with a useless description of the two original types—the Lenoir and Otto and Langen, both of course interesting in an historical account of the origin of the gas engine, but not of the slightest value or claim to notice in a pocket-book: in future editions it is to be hoped more attention will be given to this section, and that the page mentioned will be cut out. The author would have done well to make use of the recent determination of the mechanical equivalent of heat; most engineers are now adopting 778 as the figure. On p. 93 occurs an awkward misprint in the formula for mean pressure of steam; the letter in the denominator should be R, and not P, as printed. The rules given for the cooling surface of surface condensers, on p. 113, must apply only to single-cylinder engines; at any rate, they give areas greater than usually adopted in the best modern practice for triple compound plants. The sections devoted to pipes and gearing are admirable, and there are many most useful tables; the last fifty or sixty pages contain a valuable collection of tables of weights of various sections of iron and steel, areas of circles, cubes, square roots, &c. We have pointed out a few blemishes, but the book as a whole is very free from slips or errors, and will be, no doubt, of service to many engineers, draughtsmen, and works-managers. H. B.

Handbooks of Practical Science. No. I. *Mensuration, Hydrostatics and Heat.* Pp. 53. No II. *Chemical Experiments.* Pp. 58. By G. H. Wyatt, B.Sc., A.R.C.Sc. (London: Rivingtons, 1897, 1898.)

Science Handbooks for Laboratory and Class Room: Elementary Physics, Practical and Theoretical. First Year's Course. By John G. Kerr, M.A. Pp. 140. (London: Blackie and Son, 1898.)

Quantitative Practical Chemistry. Part I. Elementary Stage. Pp. 55. Part II. Advanced Stage. Pp. 31. By A. H. Mitchell, B.Sc. (Reading: National Publishing Association, Ltd., 1897.)

A NUMBER of simple and instructive experiments are described by Mr. Wyatt in the practical handbooks referred to above. Following sound educational principles the student is told what to do, but so far as it is practicable he is left to find out for himself the conclusions to be drawn from the experiments. In this respect the books are constructed upon the lines of others which are already in use in schools where elementary science is taught. A few practical exercises are given on the principles brought out by the experiments; but the teacher will find it necessary to considerably increase the number of these, if he wishes his pupils to remember what they have done. In his shorthand manuals Sir Isaac Pitman used to advise the students who wished to become proficient in the art of phonography to "Practice, Practice, Practice," and the same advice applies to instruction in elementary science. Not one or two, but twenty or thirty experiments are, for instance, necessary before young students can thoroughly understand the significance of the principle of Archimedes. The difficulty in the way of carrying out so much experimental work is one of time, and if a large amount of work has to be accomplished in a short time, the depth of knowledge is thinner in proportion to the area covered.

In the first of Mr. Wyatt's handbooks, the usual elementary exercises in mensuration, hydrostatics and heat are given; while the second contains simple experiments on general chemical processes, air, combustion, carbon, various common substances, such as salt, lime, &c., acids, alkalis, hydrogen, water, chalk, and important gases. Too much ground is covered in the latter volume for the work to give satisfactory results, but taken as a whole the handbook will be found very serviceable in teaching the rudiments of science.

Mr. Kerr's book on elementary practical physics has much to commend it, and deserves to be widely adopted by pupils commencing the study of physical science. The book contains about a schooly ear's work of three or four hours per week. In the first half a number of experiments to be performed by the pupils individually are described, and in the second half the chapters are more of a descriptive nature, so that they provide material for the pupil to study and wherewith the teacher may exercise him. The principles of measurement, and simple laws of mechanics, form the subjects of the experiments, and the author has introduced many ingenious methods into his work. The pupil who carries out the experiments will be given knowledge which he is not likely to forget. Moreover, as the experiments are mostly quantitative, they offer a valuable course of training for the mind.

Ability to perform simple quantitative experiments is now required by the Department of Science and Art from students of both the elementary and advanced stages of practical chemistry. The object of Mr. Mitchell's slender volumes is to supplement existing textbooks by exercises bearing upon the new requirements. Part I. contains experiments on measurement of length, volume, specific gravity and common chemical changes, and Part II. is concerned with the experiments in volumetric analysis so far as they are required of students in the advanced stage.

Researches on Tuberculosis. The Weber-Parkes Prize Essay, 1897. By Arthur Ransome, M.A., M.D. (Cantab), F.R.S., Consulting Physician to the Manchester Hospital for Consumption, &c.

THE book before us is the reprint of an essay written in accordance with certain specific regulations framed by the Royal College of Physicians. This diminishes to some extent the general value of the book, as it almost confines its contents to the individual experience and results of the author. These latter are, however, very extensive, and almost all ground of interest in this subject is to some extent covered. A lengthy chapter is devoted to the natural history of the tubercle bacillus, another to preventive and prophylactic measures; channels and sources of infection are also fully considered. The book concludes with a chapter upon the direct treatment of phthisis. In this connection it may be mentioned that the author seems to have obtained very satisfactory results from the inhalation of ozone. We are pleased that the Royal College of Physicians gave its consent to the publication of this essay, as the book will no doubt be of considerable interest to those engaged in researches upon this subject. F. W. T.

"*The Electrician*" *Electrical Trades' Directory and Handbook for* 1898. (Sixteenth Year). Pp. 918 + cxliii. (London: *The Electrician* Printing and Publishing Co., Ltd., 1898.)

The Universal Electrical Directory (*J. A. Berly's*). Pp. 1182. (London: H. Alabaster, Gatehouse, and Co., 1898.)

THESE two ponderous volumes give evidence of the remarkable growth of the electrical and allied industries during the past few years. Two large sheets, folded in the first of the volumes at the head of this notice, give particulars of the present electric supply works of the United Kingdom, and the electric railways and tramways. Very few of the supply stations were in existence at the beginning of 1890, and if the progress is as great in the next eight years as it has been in the past eight years, few districts will be without electricity for light, power and traction purposes. The biographical division of the Directory is of more than professional interest, as it contains short sketches of the careers of many

physical investigators, accompanied by numerous pleasing portraits. A steel-plate portrait of Mr. J. W. Swann heads this section.

The second Directory contains "a complete record of all the industries directly or indirectly connected with electricity and magnetism, and the names and addresses of manufacturers in Great Britain, India, the Colonies, America, the Continent, &c." Every means has been taken to facilitate reference, and to make the Directory of service to all who are concerned with electrical industries.

A Flower Hunter in Queensland and New Zealand. By Mrs. Rowan. Pp. xiii + 272. (London: Murray, 1898.)

THIS book is one to be laid down with regret, so brightly does the authoress tell of very varied scenes and experiences, and so easily is the reader carried along with her through them. There are few books of travels in which the fascination of the tropics to a naturalist is so evident, or that would more strongly arouse the desire to see for oneself what is here so well described. But the other side of the shield is no less vividly placed before the reader, and the price at which alone the pleasures of tropical travel can be bought can be well realised from it. Old travellers will find their experiences recalled, and will bear witness to the accuracy of Mrs. Rowan's descriptions alike of the beauties and of the discomforts of the tropics, and will recognise that the latter are expressed in no overstrained terms. There are many interesting references to the earlier history of the Colonies, and others, equally interesting, to points in natural history, though in a few of the latter the want of technical knowledge shows itself. Many and wonderful as are the powers of ants, observed in and authenticated from all parts of the world, we should have hesitated to believe about the nests of the green ants of Queensland, that "leaves and flowers are spun together by spiders that the ants keep for the purpose." Mr. Saville-Kent's statement that he has observed the ants use their own full-fed larvæ to supply the silk required for spinning the leaves together, affords an explanation sufficiently curious, but more in accordance with what we should expect. Numerous excellent views add to the attractiveness of the volume. It deserves, and will doubtless receive, a welcome from those interested in travels and natural history.

Introduction to Chemical Methods of Clinical Diagnosis. By D. H. Tappeiner (Munich). Translated from the sixth German edition, with an appendix on micro-biological methods of diagnosis, by Edmond I. McWeeney, M.A., M.D. (Roy. Univ. of Ireland), Professor of Pathology and Bacteriology C.U. Med. Sch., &c. Pp. vii + 152. Figs. 22. (London: Longmans, Green, and Co., 1898.)

THE little book before us consists of two parts—the first, chemical; the second, what the author calls micro-biological. The term micro-biological is an accurate one, and includes the usual bacteriological work on the one hand, and the examination of blood corpuscles and the morphological elements of the secretions on the other. Any system of classification—and one must have some—has its disadvantages: the present one seems to work very well.

The book is well up to date, serum diagnosis and the chemical examination of the gastric contents being contained in it. We think under the chemistry of the urine a method for the quantitative estimation of urea and uric acid ought to have been included. As far as we are aware, there is no book in English of such small bulk which contains so complete an account of chemical and bacteriological or microbiological diagnostic methods. It will not, of course, compete with the larger books on this subject, as, for instance, von Jaksch, but will doubtless have a sale, and deserves it. F. W. T.

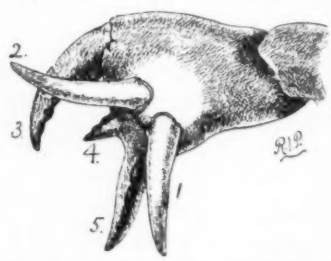
LETTERS TO THE EDITOR

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.]*

Five-fingered Crab.

DURING a recent visit to the museum at Dover, I noticed in the case allotted to the Crustacea a remarkable instance of malformation affecting the right pincer of a half-grown specimen of our common edible crab (*Cancer pagurus*); and not recollecting to have seen the like either figured or described, I venture to think the publication of the subjoined sketch, together with a few words of explanation, may prove of interest to the readers of NATURE.

A glance at this sketch will show that there are three complete subequal movable fingers or dactylopodites, numbered 1, 2, 3. Of these, number 3 clearly corresponds to the single movable finger of the normal pincer, numbers 1 and 2 being supernumerary and articulated close together upon an elevation of the hand (propodite), which is much thickened in this region. The two remaining fingers (indices) are immovable. Number 4 is very much the shorter of the two, number 5 being quite comparable in size to either of the three movable digits. Judging from its size and the spot whence it emerges from the hand, the larger index (5) represents the immovable finger of the normal pincer; but its toothed edge is directed, not towards the normal finger (3), but towards the supernumerary finger (1). The smaller index finger (4), on the contrary, has its biting margin turned towards the biting margin of the normal movable finger



(3), and in all respects, except size and point of origin, corresponds exactly to the immovable finger of the normal pincer. When the movable digits are closed, number 1 passes on the under side of 5, number 2 on the upper side of 3, and number 3 shuts directly upon 4.

I am only acquainted with records of two cases of malformation in crabs' claws resembling this specimen in the Dover Museum. One of these is figured and described by Mr. Bateson (*Materials for the Study of Variation*, p. 530, No. 815; also *Proc. Zool. Soc.*, 1890, p. 581); the other by M. Sénéchal (*Bull. Soc. Zool. France*, 1888, p. 123). In the former, however, the supernumerary movable fingers numbered 1 and 2 in the figure of the Dover specimen are represented by a single dactylopodite, which, nevertheless, shows its double nature by being divided at the tip and furnished with two rows of teeth along its biting edge. In the example observed by Sénéchal, on the contrary, there are three complete movable digits arranged apparently very much as in the specimen here described and figured; but the process from the propodite (hand) is represented by a broad plate consisting of three only partially separated indices.

February 27. R. I. POCOCK.

Dew and Absorption.

I AM engaged on some daily experiments with a view to measure dew as rain in lineal inches. At present, however, I cannot distinguish between dew and absorption.

I fill a small cylinder (A) of tinned iron—a tobacco canister—to within about 1 inch of the top with garden soil, dry it at 212° F., weigh, expose it over-night, and re-weigh at 9 a.m. before the sun comes on it.

I now purpose to expose another similar tin (B) with ten circular holes pierced near its rim, and covered with a horizontal glass plate.

I hope that B may give some measure of *absorption*, and A—B some measure of *dew*.

I reckon grammes of weight gained as cubic centimetres of water, divide this number by the number of sq. cm. in the circular opening, and take the quotient thus obtained as the measure in linear cm. of dew as rain.

I shall be greatly obliged if any readers can refer me to previous experiments that have been made in this direction.

Harpenden. T. WILSON.

Oat Smut as an Artist's Pigment.

WITH regard to Prof. Marshall Ward's note under this heading (p. 389, *ante*), I may add that, according to Mr. K. Miyabe, the olive-brown spores of *Ustilago esculenta* ("Makomo-zumi" in Japanese), besides its application to the painting of the ladies' eyebrows in Japan, are mixed up with oil and smeared on the scalp and hairs by older women who have the hairs thin or grey. "At present," the author adds, "the spores are largely used in the lacquer industry to produce rusty-coloured wares by mixing them with lac" (*The Botanical Magazine*, Tôkyô, vol. ix. p. 197, May 1895).

KUMAGUSU MINAKATA.

February 25.

GEOLOGICAL PHOTOGRAPHS.

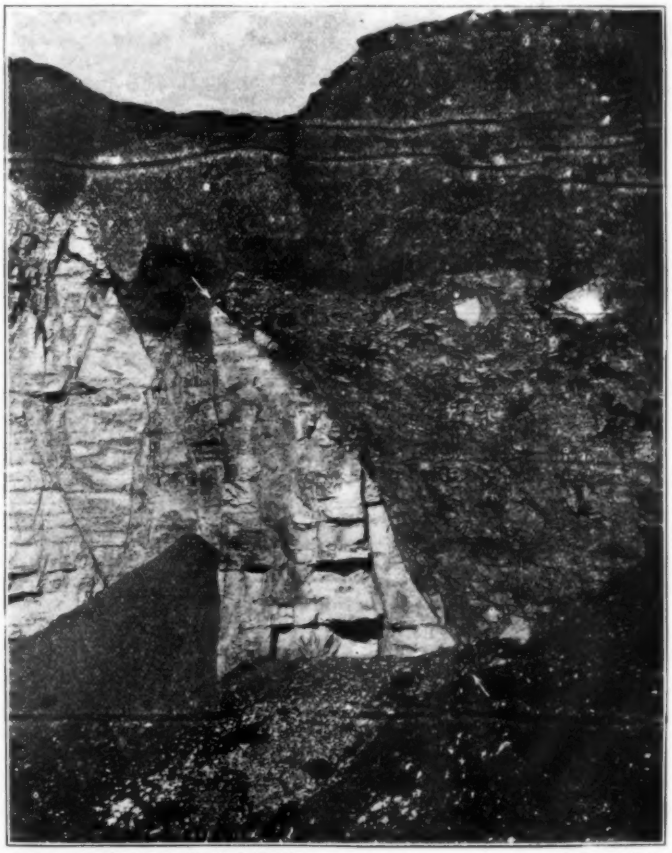
THE Committee appointed by the British Association for the collection and safeguarding of photographs of geological interest has a good record of work to show for the past year. The entire collection of 1750 prints is now uniformly mounted and deposited in the library of the Museum of Practical Geology at Jermyn Street. Over 350 new prints were received during last year. A new feature has been the formation of a collection of picked duplicates illustrating typical geological phenomena which, in the form of prints or lantern slides, can be lent to local scientific societies or others desiring either to know what work the Committee is doing, or to help on the work.

No less than 119 of the new photographs come from Ireland, and the north of that country is now well illustrated. As is well known, the geology of this region is exceptionally interesting as it was the site of a great volcanic outburst in Tertiary times, and the columnar lavas and sills, the dykes intrusive into chalk and into newer and older rocks, the laccolites, volcanic necks and ash beds, form a text-book of volcanic geology. One of the most remarkable localities is Cave Hill, near Belfast, where the unconformable junction of the chalk with the lavas has been well exposed by the quarrying operations.

The remarkable section shown in the annexed figure (Fig. 1) is reproduced from an excellent photograph by Mr. R. Welch, of Belfast. Unfortunately the section is now being destroyed by quarrying, so that this photograph is the best record we possess of it. It shows an old, steep, pre-Tertiary cliff of chalk which was gradually buried in débris, most of which was derived from itself. Both cliff and débris were buried by basaltic lavas and ash beds thrown out by the volcanoes which broke out along great fissures in early Eocene times.

Glacial phenomena admit admirably of registration by photography, and the collection is fairly rich in such illustrations.

Although Ramsay many years ago wrote an account of the glaciation of North Wales, comparatively little connected work has been since done to elucidate this remarkable example of upland glaciation, while a complete photographic record of it remains to be executed. Some few points have, however, been dealt with, notably by the late J. J. Cole, Messrs. Williamson and Wills, Mr.



[Photographed by Mr. R. Welch, Belfast.] [Copyright.

FIG. 1.—Cave Hill, Belfast.

Godfrey Bingley, Mr. Atchison and others, and the work is in the collection. Good as it is, however, serves best to show how much in the way of systematic recording there is still left to be done. Some one should set to work with Ramsay's book in his hand, visit the localities mentioned, photograph them, and, guided by it, seek out and record a complete account of the glaciation of the entire region; and he cannot do better than begin on Snowdon. Just opposite Snowdon, on a small hill, Y Foel Perfedd, above Pen-y Pass Hotel, the perched block shown in Mr. Bingley's photograph (Fig. 2), of which a reproduction is annexed, overhangs the Pass of

Llanberis, and looks as if a mere touch would precipitate it into the Pass below.

Photographs have often been taken of single examples of fossil trees in submerged forests and in the coal-measures or other rocks. But it is not often that a whole forest of Carboniferous trees is exposed to-day in quarrying operations, and it is still more rare to have them preserved for future generations by a building, as has been done in the instance from Partick, figured below. This photograph was taken by Mr. R. McF. Mure, of Paisley, who has kindly furnished me with particulars as to the size of the trees: the stems are most of them over two feet in diameter at the base, and the spread of the roots in some cases is correspondingly large.

W. W. WATTS.

Photographed by Mr. G. Bingley, Headingley, Leeds. [*Copyright.*

FIG. 2.—Y Foel, Perfedd, Llanberis.

Photographed by Mr. R. McF. Mure, Paisley. [*Copyright.*

FIG. 3.—Carboniferous Forest, Partick, Glasgow.

SOME RARE BIRDS' EGGS.

ON comparing the numerous works which have appeared of late years on British birds with their predecessors of a couple of decades or more ago, we cannot fail to be struck with the great diminution in the number of species whose eggs and nests are stated to be unknown. And since the appearance of even the more recent of these, one more gap has been filled up by the announcement of the discovery by Mr. Popham, last July, on an island in the mouth of the Yenisei, of the long-sought eggs of the curlew-sandpiper (*Tringa subarquata*). By this fortunate discovery the number of species entitled, even by the utmost stretch of courtesy, to be included in the British list whose eggs still remain unknown, is very small indeed, although there are several species of which the known specimens are extremely few. Of course there are a host of foreign birds whose nidification awaits discovery, but to mention even a portion of these would obviously be impossible within the limits of an ordinary article. The majority of the British species whose breeding haunts offered the longest resistance to the efforts of egg-hunters, were those which migrate at this season to the desolate Arctic tundras; and among the eager explorers of the avifauna of those regions the name of John Wolley will always stand pre-eminent, ably as his pioneer efforts have been seconded and completed by men of the stamp of the late Mr. H. Seebohm and Colonel Feilden, to say nothing of many equally enthusiastic and capable observers. At the present day one of the great fields remaining for exploration are the breeding areas of many of the species inhabiting the southern hemisphere.

In many respects birds' eggs have proved a somewhat disappointing study, since, if we except their aid in bringing about the recognition of the intimate structural affinities existing between the Limicolæ and the Gaviæ, they have afforded comparatively little assistance in unravelling the tangled skein of avian relationships. And many of the generalisations which have been drawn from them, such as those relating to white eggs, have turned out to be true only in part. Moreover, it is unlikely that those remaining to be discovered will add anything really important to our stock of knowledge. The newly-discovered eggs of the curlew-sandpiper, for example, do not differ from those of the allied forms in any more important degree than do the different postage-stamps of the same issue.

Not that the quest of birds' eggs is in any way to be discouraged—far from it. While the eggs themselves, from the intrinsic beauty of their shape and coloration, form a never-ending source of delight to the collector, it is only through the energy of the hunter after these spoils that a knowledge of the habits of the birds themselves can ever be attained. In the words of Prof. A. Newton, it is the field naturalist who alone crowns the

labours of the anatomist and the museum-worker. "What engineer," writes the Professor, "can be said to understand his business if he knows not the purpose to which the machines he makes are to be applied, and is unacquainted with their mode of working. We may investigate thoroughly the organs of any animal, we may trace them from the earliest moment in which they become defined, and watch them as they develop to maturity, we may comprehend the way in which every part of a complicated structure is built up; but if we take not the trouble to know their effects on the economy of the creature, we as naturalists have done but half our task, and abandon our labour when the fulness of reward is coming upon us." All honour then to those (if only they work in the right way) who risk their health, if not their lives, and spend their treasure, in the quest of the rarer birds' eggs!

Although they have been removed from the list of desiderata, the eggs of the curlew-sandpiper will probably long remain among the rarest of those of the British species, those from the Yenisei being the only specimens at present known. Among the species included in the British lists whose eggs were unknown at least as late as 1896, is Pallas's grey shrike (*Lanius sibiricus*), but as this bird is so closely allied to the ordinary species, their discovery cannot be looked forward to with any special interest. The second is the needle-tailed swift (*Chætura caudacuta*), which has only twice been seen in Britain, and breeds in northern Asia, although its eggs are still unknown. Equally slight are the claims of the sharp-tailed sandpiper (*Tringa acuminuta*) to be regarded as British; and, although still unknown, its eggs will probably prove very similar to those of the American *T. maculata*. To the rare and beautiful wedge-tailed gull (*Rhodostethia rosea*), reported to have been once seen in Britain, is provisionally assigned a single egg in the British Museum obtained from Disco Bay. Of far more interest would be the discovery of the eggs of the Cape petrel (*Daption capensis*), since this bird, of which an example was killed in Dublin in 1881, represents a genus by itself. One of its breeding-places appears to be Kerguelen Island. Of two other petrels, namely *Œstrelata hæsitata* and *Œ. brevipes*, with equally slight claims to admission in the British lists, the eggs are likewise unknown.

Of species whose eggs are known, although of extreme rarity, next to the curlew-sandpiper, the white-billed diver (*Colymbus adamsi*), a by no means very rare visitor to our coasts, may first claim attention. The only known eggs, which are very like those of the great northern diver, were obtained during the voyage of the *Vega* in 1879. Of the lovely ivory gull (*Pagophila eburnea*) the eggs have been described by Prof. Collett; while those of the Iceland gull (*Larus leucopterus*) and Mediterranean black-backed gull (*L. melanocephalus*) come also under the category of rarities, the nest of the latter species being unknown. Of greater interest are the beautiful eggs of the Sandwich tern, of which additional specimens were recorded last year. Although obtained by Wolley, the eggs of the spotted redshank (*Totanus fuscus*) must be regarded as prizes by the collector; while so late as 1893 those of the solitary sandpiper (*T. solitarius*) were recorded by Mr. Dixon as unknown, although one clutch has been described by Mr. Elliot, in which the eggs resembled those of the piping sand-plover. Claim to a place in this section is undoubtedly held by the sanderling, of which eggs were obtained by MacFarlane in Arctic America in 1863, and subsequently by Colonel Feilden in Grinnell-land. The knot (*Tringa canutus*) is another of the species which appears in Mr. Dixon's book of 1893 as among those of which the eggs are unknown. It seems, however, that a clutch of four was taken in Greenland as far back as 1875, one of which is now in the British Museum; and these, with a single specimen taken from the body of a female by Lieut. Greeley, appear to be the only examples in collections. Far less uncommon are the eggs of the little stint (*T. minuta*), although they still come under the category of rarities, as do those of the jack snipe, which were first taken by Wolley in Lapland. The crestless lapwing (*Vanellus gregarius*), of which but one British specimen is on record, is also a bird of whose nidification details are wanting, although the eggs are known to be four in number, and very similar to those of the crested species. Dotterel eggs, although very handsome, can now scarcely be considered as rarities; but those of the lesser golden plover (*Charadrius dominicus*) are very scarce, although their similarity to those of the ordinary species renders them less interesting than would otherwise be the case.

Passing other members of the foregoing groups whose eggs are more or less scarce, allusion must specially be made to the common bernicle goose, of which it is a remarkable fact that eggs laid in a wild state are quite unknown, although this is somewhat discounted by the circumstance that birds have nested in captivity. Of the nearly allied red-breasted bernicle (*Bernicla ruficollis*) the eggs have, however, been discovered, and, except for their somewhat smaller dimensions, are stated to be indistinguishable from those of the bean-goose.

Although the eggs of all the species of birds of prey recorded as British are known, some are comparatively rare in collections. Among such may be mentioned those of the red-footed kestrel (*Falco vespertinus*), which although not uncommonly taken in Russia, were so poorly represented in the British Museum in 1896 that Dr. Bowdler Sharpe stated he was unable to properly define their characters.

In addition to those of Pallas's shrike, which have already been mentioned in the unknown list, the following are some of the rarer eggs among the British Passerines. From their beautiful markings the eggs of all the buntings are always favourites with collectors; and from their rarity those of the rustic bunting must be specially prized. Two only are in the Seebohm collection in the British Museum, although others have been described by Mr. Dresser, and yet others are mentioned by Prof. Newton as among the specialities of last year's collecting. Richard's pipit (*Anthus richardi*) affords an example of a bird of which the eggs are known, but the nest has never been described. Among comparative rarities the eggs of the yellow-browed willow-warbler (*Phylloscopus superciliaris*) and the marsh-warbler (*Acrocephalus palustris*) deserve passing mention, especially as many referred to the latter species appear to be nothing more than pale examples of the reed-warbler. Perhaps the greatest prizes among the British representatives of the group are, however, the eggs of White's thrush (*Turdus varius*). A nest, with eggs, from Ningpo attributed to this species is included in the Seebohm collection, and undoubted specimens are mentioned in Prof. Newton's list of new acquisitions. Less rare are the eggs of the black-throated ouzel (*T. atrigularis*), of which several clutches have been taken in the Altai, although the nest is still unknown. Another desideratum is the nest of the Siberian ground-thrush (*T. sibiricus*), of the eggs of which three specimens taken in Japan, and now in the Seebohm collection, were the only examples known up to 1896. Of the Arctic blue-throat (*Cyanecula suecica*) the eggs, which resemble those of a redwing in miniature, are far less rare, but must still be reckoned as among the collector's choicest treasures.

To go further into the British list would be beyond the limits of this article, while, as already said, species not occurring in that list must be excluded. An exception may, however, be made in favour of the rare Pander's chough-thrush (*Podoces panderi*), of the deserts of Central

Asia. Of this bird the eggs were first obtained, we believe, by Fedtchenko, and have ever since ranked as great rarities, and collectors will therefore be interested in finding specimens included among those collected last year and mentioned by Prof. Newton. R. L.

NOTES.

THE Council of the Royal Society have invited Dr. Wilhelm Pfeffer, professor of botany in the University of Leipzig, and foreign member of the Royal Society, to deliver the Croonian Lecture on March 17. The subject of the lecture is to be "On the Nature and Significance of Functional Metabolism (*Betriebsstoffwechsels*) in the Plant." The lecture will be delivered in German. Prof. Pfeffer is well known among botanists for his two volumes on "Pflanzenphysiologie," published in 1881 from Tübingen, and the second edition of which was issued last year; while his views on the function of chlorophyll, and its absorption-spectrum, are familiar to workers on the physiology of plant-life.

MORE than 100 foreign zoologists have now consented to be members of the "Committee of Patronage" of the Fourth International Congress of Zoology, and a large number of them have expressed the hope that they will be able to be present at the meeting in August next. Among these we may mention the names of Prof. Häckel, of Jena; Prof. Graff, of Graz; Prof. Grassi, of Rome; M. Blanchard, of Paris; Baron Jules de Guerne, who has been associated with the Prince of Monaco; Dr. Jentink, of Leyden, who was President of the Third Congress; Dr. Dollo, of Brussels; and Prof. Collett, of Christiania. From the United States it is hoped there will be a somewhat large contingent; Profs. Osborn and Scott, Prof. E. B. Wilson, and Mr. Watasé, of Chicago, all hope to be able to come.

THE sixth "James Forrest" Lecture of the Institution of Civil Engineers will be delivered on Thursday, March 17, at eight o'clock. Prof. W. Boyd Dawkins, F.R.S., the lecturer, takes for his subject "Geology in relation to Engineering."

THE Mayor of Bradford presided at a meeting, held on Monday, for the purpose of considering a proposal to invite the British Association to Bradford for the year 1900. It was unanimously decided to send an invitation to the Association for the year 1900, and an executive committee was appointed to make arrangements if the invitation should be accepted.

IT is expected that some of the observers of the recent total eclipse of the sun will give a preliminary account of their observations at the meeting of the Royal Astronomical Society to-morrow.

THE Municipal Council of Paris have inserted in the budget for this year the sum of ten thousand francs, for the laboratory of photography and radiography at the Salpêtrière.

THE following grants have recently been made by the Trustees of the Elizabeth Thompson Science Fund:—250 dollars to Prof. Gustav Hüfner (Tübingen), for the investigation of hæmin and hæmatine; 288 dollars to Prof. Carlo Bonacini (Modena), for researches in colour photography; 250 dollars to Prof. John Milne, to aid in a seismic survey of the world.

THE Zürich correspondent of the *Times* states that the observatory on Mont Blanc, which was constructed by M. Joseph Vallot some seven years ago, is to be transferred to another site. The present structure is built on a small rocky plateau, which extends for a short distance from the Rochers des Bosses, but its position is no longer favourable for scientific observations. The construction of the building has served as a barrier against which the snow piles itself in ever-increasing masses, causing both trouble and expense to the observatory staff. The whole erection is to be transferred, piece by piece, on the backs of workmen from the Rochers des Bosses to a rocky point at the same altitude, where the ground will first be levelled by blasting, and, in spite of the difficulties of climate and transport attending these operations, it is hoped that the whole transfer will be finished in the course of one summer season.

AT the meeting of the Entomological Society of London on March 2, a discussion took place on the reported introduction of the San José scale, *Aspidiotus perniciosus*, into Great Britain. Mr. R. Newstead, the only British entomologist who is now specially occupied with Coccidæ, stated that during the past nine years he had never once met with this species among the numerous scale-insects taken in this country and forwarded to him for identification. It was impossible even for an expert to distinguish it, without careful microscopical preparation and examination, from among the thirty or more described species of *Aspidiotus*, and any attempt to identify it on imported fruit by naked-eye observation, or with a hand-lens, was therefore quite impracticable. The risk of its distribution by importation on fruit was small; there was, however, much more likelihood of its introduction on plants or trees. At the same time he saw no reason to suppose that it would be more injurious in this country than the common *Mytilaspis pomorum*; in America the San José scale had several, sometimes as many as five, generations in the year, but in this climate it would probably conform with the habits of all other scale-insects at present investigated and become single-brooded. Mr. Newstead's conclusions were generally agreed with by the Fellows present.

ACCORDING to the *Bulletin de la Société Française de Physique*, M. Crémieu has devised an ingenious means of producing elliptic sound-vibrations in air. By the interference of the longitudinal vibrations of two organ-pipes, placed at right angles, and vibrating under the influence of two diapasons with the proper difference of phase, an elliptic motion was set up at the intersection of the tubes, and its existence was made evident by means of delicate quartz fibres which followed all the movements of the air.

M. A. LEDUC, in a paper read before the Société Française de Physique, criticises the well-known law of mixture of gases, according to which the pressure of a mixture is the sum of the pressures of its constituents at the same volume and temperature. This law is only true for perfect gases, and is then equivalent to the statement that the volume of the mixture equals the sum of the volumes of its constituents at the same pressure and temperature. From experiments on several gas-mixtures, M. Leduc considers that the second form of the law is rigorously applicable to certain mixtures of real gases, and is, in general, in closer approximation with experiment than the first.

IN the *Annales du Bureau Central Meteorologique*, M. Moureaux gives an account of the different comparisons he has made between the magnetic instruments of the Parc Saint Maur Observatory and those of the observatories at Kew, Uccle (Brussels) and Pavlovsk (St. Petersbourg). The comparison observations made at Kew have already been described by Mr. Chree in a communication to the Royal Society. The declination at Pavlovsk was found to be 1′·3 higher than the French standard, the horizontal force 0·00013 lower, and the dip 0′·8 lower. At Uccle the declination was 1′·5 lower, the horizontal force 0·00002 lower, and the dip was not compared. In the account of the Kew comparisons an arithmetical error occurs which makes the horizontal force difference 0·00011 when it ought to be 0·00012.

IN connection with recent measurements of the temperature of the air at high altitudes, Signor Luigi de Marchi, writing in the *Rendiconto del R. Istituto Lombardo*, discusses the validity of Mendeléef's and Herschel's laws connecting temperature with altitude, and draws conclusions which may be briefly summed up thus:—(*a*) Recent measurements of temperature of the higher strata of the atmosphere can be represented by a formula of the type of Mendeléef's, viz. $t + C = (T + C)p/P$, where, however, C increases with the altitude; (*b*) for altitudes below about 4500 metres the formula agrees with observation when C is taken as a linear function of the altitude, but for greater altitudes, up to 13,000 metres, the supposition that C is a linear function of the pressure gives the best results, the formula then reducing, like Herschel's, to an equation of the second degree in p; (*c*) for altitudes of a few thousand metres Mendeléef's formula gives sufficiently approximate results when C is taken to be constant; (*d*) the validity of the proposed formula, if substantiated by further observations, would confirm the hypothesis that the temperature of a stratum at any given altitude is determined principally by the equilibrium between the thermal radiations which it receives from the ground, and which it emits into the sky, when the assumed law of radiation is that of Newton or of Stefan. The latter law in the strata hitherto reached would lead to a formula less reconcilable with the data of observation than the former.

ONE of the difficulties which water-engineers have to face is the unpleasant odour which sometimes characterises surface waters stored in open reservoirs. Such odours are frequently supposed to be due to the decomposition of organic matter in the water, but, although such may be the case, in many instances they have been found to be attributable to the growth of microscopical organisms, and quite a long list has now been furnished of vegetable growths which impart disagreeable tastes and smells to water. Messrs. Jackson and Ellms have just published a memoir describing their investigations upon one of the *Cyanophyceæ* or blue-green Algæ which, when growing in water, impregnates the latter with a most unpleasant mouldy grassy smell. Pure cultures of *Anabæna circinalis*, an important offender in this particular, were obtained and numerous experiments were carried out. As in the case of other microscopical water-organisms, the odour emitted during growth was found to be due to the presence of certain compounds of the nature of essential oils which make their appearance at a particular stage of growth. The investigation was also extended to an examination of these Anabæna during decay, a most offensive odour being given off during decomposition. This the writers think is probably due to the high percentages of nitrogen which these growths contain. The gas given off during decomposition was analysed and was found to contain a large percentage of hydrogen, and a considerable proportion of sulphur compounds. Analyses of the decayed gelatinous material resulting from the decomposition of Anabæna revealed the presence of a large amount of sulphur and a considerable amount of phosphorus. The subject is of such importance in connection with the storage of surface waters, that the closer study of the chemical composition of these organisms and of the organic and mineral contents of the waters which the various genera infest, is well worthy of attention; for by extending our knowledge in this manner, we should be better able to judge beforehand of the likelihood of particular waters becoming subject to these unpleasant changes on storage. The above memoir is to be found in vol. x. of the *Technology Quarterly*, Massachusetts.

THE receipt by the University of Pennsylvania of a collection of mammalian fossils from the tundra at the back of Point Barrow, Alaska, has induced Mr. S. N. Rhoads to put together the available information on the living and extinct species of North American *Boves*. Mr. Rhoads refers one of the Alaskan Bison-heads to an unnamed species which he proposes to call *Bison alaskensis* (*Proc. Ac. N.S. Phil.*, 1897, p. 490). He has likewise taken this opportunity to examine the question of the so-called "Woodland Bison" of the Peace-River district of Athabasca. It appears that an adult male specimen of this little-known animal has recently been obtained by the Geological Museum of Ottawa. Mr. Rhoads describes this example from information sent to him by Prof. J. Macoun, and refers it to a new sub-species, *Bison bison athabascæ*, separating it from the typical form on account of its "great size, darkness of colour, and the characters of the horns and horn-cores."

AN interesting article on the wild cattle of Chartley, Staffordshire, is contributed to *Nature Notes* by Mr. J. R. B. Masefield. This herd of wild white cattle is of great antiquity; but whether the present animals are directly descended from some one of the ancient native species, such as *Bos primigenius*, *Bos longifrons*, &c., or whether they are descendants of domestic cattle introduced by the Romans and run wild, is still an undecided question. The home of these cattle is situated on high ground some 300 feet above sea-level, and was enclosed about the year 1200, and forms a portion of Chartley Park, some five miles from Uttoxeter, the nearest town. The extent of this wild tract of table-land is about 1000 acres, covered with coarse grass, rushes, stunted bilberries, and heather, and patches of luxuriant bracken fern, with a few clumps of old weather-beaten Scotch firs and birch, which afford some shade from the hot summer sun. Among the other denizens of this wild primeval tract are herds of red and fallow deer and multitudes of rabbits, (with no doubt a few of their natural enemies, the stoat and voles—both the common vole and red bank vole), moles, long-tailed field mice, shrews, weasels, and adders. The theory that the Chartley breed of wild cattle is indigenous appears to be supported by their general habits at the present day. When alarmed they start off at full gallop for a short distance, then turn and face their foe in a semicircle, with the bulls in front, the cows behind, and the younger animals and calves still further in the rear. If closer approached, these tactics, which are clearly those of wild animals, are repeated, or the adversary is charged and attacked. Again, they conceal their young in fern or long rushes, and the cows, when calves are born, become exceedingly fierce and dangerous, especially if an intruder should get between a cow and her calf. Mr. Masefield points out that a fine herd of white cattle, very strongly resembling the Chartley breed, are to be found at Lamphey Court, near Tenby, in South Wales; they are said to belong to an old Welsh breed, but in colour and general appearance it is difficult to distinguish them from the Chartley animals.

M. P. VUILLOT has completed a map of the lake districts of Timbuktu on the scale of 1/100,000, which contains a number of topographical discoveries in this little-known region. In presenting the map to the Paris Geographical Society, M. Vuillot adds an interesting note on the hydrography of the area, and on its productiveness, which has been published in the Society's *Comptes rendus*.

PROF. THEOBALD FISCHER contributes a short paper to *Petermann's Mittheilungen* on the "moraine-amphitheatre" of the Lake of Garda. The form of the moraine deposits on the inner or Italian side of the Alps differs markedly in type from that on the outer or German side. In the former type, of which the Lake of Garda affords an excellent example, the deposits are laid down in concentric ramparts which turn their convex side to the plains; while in the latter we find the familiar expanded fan shape at the mouths of the valleys. Dr. Fischer avails himself of the very excellent maps and models furnished by the Italian Service.

THE first two numbers of the new volume of the *Mittheilungen* of the Vienna Geographical Society are devoted to a memoir on he Hallstätter See, by Dr. Lorenz, Ritter von Liburnau, which extends to over 200 octavo pages. The form and position of the lake are discussed, chemical analyses are given of its waters and of the waters of the inflowing streams, and there are elaborate investigations into the distribution of temperature at different depths and at different seasons, into currents, transparency and colour of water, and the various forms of life. Dr. Lorenz had the assistance of a large number of colleagues in making his observations, and was fortunate in having a steam launch placed at his disposal free of cost.

Petermann's Mittheilungen contains an account of a recent expedition into the interior of Dutch East Borneo by Dr. A. W. Nieuwenhuis. The region between the upper basins of the Kapuas and the Kutei or Mahakam rivers was not visited by the Dutch expedition of 1894, owing to the supposed hostility of the natives; but by judicious treatment and selection of native companions, Dr. Nieuwenhuis has succeeded in exploring a considerable area. A stay of eight months was made at a station on the Bloeoe, a small right-bank tributary of the Mahakam, giving opportunity for detailed topographical and geological surveys. Extensive collections were made, which have reached Buitenzorg in safety.

IN descending the Niger, the Hourst Expedition found the navigation of that river impeded by rapids from Ansongo to below Boussa. As this was during the season of high water, M. le Lieut. de Chevigne was detailed in May 1897 to make a further reconnaissance when the river was at its lowest. The results of his observations are published in the *Comptes rendus* of the Paris Geographical Society, and are described as of special importance on account of a French station having been recently established at Say. The Niger is to be considered as navigable from Timbuktu to Ansongo, but only during high water; below Ansongo, rocky shallows and rapids render navigation difficult at all seasons, and dangerous, if not impossible, for nine months in the year.

IN the *Bulletin* of the Imperial Society of Naturalists of Moscow, No. 2 for 1897, is a lengthy and important paper (in German) by C. Sokolowa, on the growth of root-hairs and rhizoids. He appears to have come to the conclusion that neither the growth of the cell-wall nor the currents in the protoplasm are directly dependent on the cell-nucleus, although the position of the nucleus appears to a certain extent to determine the direction of the currents. N. Malischeff contributes some remarks on the nerve-endings in the œsophagus and stomach of birds. The remaining papers are in Russian.

DR. F. VON KERNER publishes a short account of some recent geological work on the coast regions of Dalmatia in the *Verhandlungen* of the Austrian Geological Survey. The peninsula of Ostrica, the island of Zlarin, and a number of the neighbouring rocky islets were surveyed, disclosing some features of geological and geographical interest. The islands together form part of the submerged lower course of the river Kerka.

AT the recent Ithaca meeting, the Association of American Anatomists adopted the report of the majority of the Committee on Anatomical Nomenclature, and ordered it to be published and distributed as soon as practicable, accompanied by the objections of the minority of the Committee, and comments thereon by the Secretary of the Committee. Of the neural terms recommended, more than 100 were identical with those adopted in 1895 by the Anatomische Gesellschaft.

WITH reference to our note on M. J. Deniker' papers on the characteristics of the inhabitants of the various districts o Europe (p. 351-2), the author writes to correct an error which unfortunately crept into his paper. In our note, p. 352, line 14, the race "(β) Blond, mesocephalic, very short," should be ascribed to Saxony-Poland instead of Sweden.

THE additions to the Zoological Society's Gardens during the past week include a Masked Paradoxure (*Paradoxure larratus*), a Large Indian Civet (*Viverra zibetha*) from Western Szechuen, China, presented by Mr. Julius Newmann; three Punjaub Wild Sheep (*Ovis vignei*, ♂ ♀ ♀) from Southern Persia, deposited; a Common Seal (*Shoca vitulina*) from Holland, an Indian River Snake (*Tropidonotus piscator*) from India, purchased; a Leopard (*Felis pardus*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

OCCULTATION OF ANTARES.—The occultation of a star of the first magnitude is of rare occurrence, more especially when the moon is at such a favourable age as in the case of the occultation of Antares (α Scorpii) magnitude 1·1, on March 13, when the moon is in the last quarter. The times of disappearance at the bright edge and reappearance at the dark edge, as given in the *Nautical Almanac*, for Greenwich are 14h. 38m. 0s., and 15h. 49m. 0s; and the angles at which these respective phenomena take place are 111° and 305°, measured from the vertex. The occultation of this beautiful red star is a most interesting observation, especially at the favourable phase of the moon, which should render the doubling of Antares easily visible. It was during an occultation that Burg discovered the celebrated blue companion in 1819.

NAUTICAL ALMANAC, 1901.—The *Nautical Almanac* for the year 1901 has just been issued. It is arranged in a similar way to those now familiar to us, and from it we learn the details of the total eclipse of the sun which takes place in that year on May 17. The path of the shadow passes over Sumatra, Borneo, Celebes, and the southern part of New Guinea; the eclipse will also be visible in Australia, but only as a large partial one, whilst in Europe and America no trace of it can be observed. This eclipse is remarkable for being one in which the duration of totality is nearly the longest possible, the maximum obscuration of the sun lasting about six and a half minutes.

We notice also that in accordance with the decision of the Paris Conference on Fundamental Stars, held in May 1896, the constants of precession, nutation, aberration and solar parallax, as set forth at that meeting, have been adopted. The new value for the solar parallax is, therefore, 8″·80 instead of 8″·848, and this is probably correct to within 0″·02.

Part I. of the *Almanac* is issued separately, as of late years, and contains such information as is essential to navigators.

VARIABLE STAR U PEGASI.—In a recent issue of NATURE, p. 352, we noted Mr. O. C. Wendell's observations of the short-period variable, made at the Harvard College Observatory, and the results of which were issued by Prof. Pickering in Circular No. 23. In the *Astronomical Journal*, No. 426, Mr. Chandler brings data together to show that the light curve is, as was originally laid down, of single period, and not analogous to that of β Lyræ, with a small difference of 0·15 mag. between the primary and secondary minima. He also points out that the polarising photometer failed to make manifest the secondary minimum of the star Z Herculis, a phenomenon involving a difference of nearly 0·5 mag., or three times the amount in question.

In Circular No. 25 (on polarising photometers), Prof. Pickering points out that the objections to the first form of photometer have been remedied, and now the emergent pencils of the images compared coincide, and a surprising degree of accuracy may be obtained in the measures, which is illustrated by numbers from actual observations. He also gives the individual results derived from Mr. Wendell's observations, and these show that the largest value of the secondary minimum is 0·05 mag. less than the smallest value of the primary minimum. Besides this he shows that if the minima be assumed to be equal, the residuals at first minimum have a mean value of +0·064, and at the second the mean value is −0·070. He concludes that "the probability, therefore, that the two minima are really equal and that these deviations are due to accidental error is extremely small; and it is very singular that if these deviations are due to systematic error, that it has one value at principal minimum and another at secondary minimum."

THE PHOTOGRAPHY OF NEBULÆ.

PHOTOGRAPHY has been a helpful handmaid in many branches of astronomical science, but in no department is the value of her assistance more clearly seen than in that which is concerned with the forms and structures of nebulæ. This is hardly to be wondered at when the fine texture, the almost imperceptible gradations of light, the intricacy of detail, and the variety of nebulous forms are considered. Many vigils must be kept by an astronomer before the trend and comparative distinctness of a particular nebulous feature is satisfactorily observed; and even where this has been done, to represent the characteristic faithfully is beyond the power of any but the most accomplished draughtsmen. The unimaginative photographic plate, however, looks heavenwards for a few minutes and has imprinted upon it not only the delicate details which tease the eye of the observer and elude the skill of the artist, but also records a greater extent of celestial mist than the human eye is capable of grasping. On this account exceptional interest is attached to what has been accomplished in the portraiture of nebulæ, and the following survey of the subject will serve to show some of the roads along which progress has been made.

EARLY DAYS OF NEBULAR PHOTOGRAPHY.

Dr. Henry Draper was the pioneer of nebular photography; he succeeded in obtaining a photograph of the nebula of Orion on September 30, 1880. ("Washington Observations," vol. xxv., 1878. Appendix i. p. 226.) Only the brightest parts of the nebula were comprised within the picture; nevertheless, the result was such as to show that photography had great possibilities before it as a delineator of nebulæ. Encouraged by the tangible fruits of his labour, Dr. Draper took a number of photographs of Orion's nebula, and in March 1881 obtained a picture showing stars fainter than the fourteenth magnitude; that is, stars only just within the limits of visibility of the telescope employed in the work. This fact was not lost upon him, for in a short note communicated to the Paris Academy of Sciences in April 1881 (*Comptes rendus*, vol. xcii. p. 964, 1881), he remarked that astronomers might reasonably expect to photograph stars which were quite beyond the visual reach of the most perspicuous observer; in other words, that a sensitive plate at the eye-end of a telescope could see objects which were too faint to produce any impression upon the retina of an observer using the same instrument. The picture which led to this remark was taken with an exposure of 104 minutes. Towards the beginning of the following year, a fine negative was produced by exposing a gelatino-bromide plate to the nebula for 137 minutes. This photograph comprised more of the nebulous matter, and especially of the delicate outlying parts, than any of the previous ones. In commenting at the time upon the strikingly perfect representation of the nebula afforded by the picture ("Washington Observations," vol. xxv.; Appendix i. p. 227), Prof. E. S. Holden compared it with Bond's drawing of the same object. This observer spent several years scrutinising the nebula, and, as a result of his patient observation, was able to produce a picture which represented its features with greater accuracy and artistic effect than had previously been attained. Dr. Draper's photograph of the nebula was taken in a little over two hours, yet Prof. Holden confessed that for nearly every purpose it was incomparably better than Bond's hand-drawn picture. It was evident from this that a new epoch of nebular observation had been opened. Exact and automatic representations of nebulæ were to take the place of the strange, and often crude, drawings of these objects. The new method inaugurated by Dr. Draper has developed so much that, at the present time, it may almost be said that photography entirely holds the field as a nebula-artist.

A nebula rarely has a definite form, like the sun and moon. It presents the appearance of a cloud having more or less irregular outlines, and of which the various parts differ greatly in brightness. It results from this that photographs of the same nebula may be very different in appearance, for their characters depend upon the power of the telescope employed in their production, the time during which the sensitive plate was exposed, the sensitiveness of the plate, the transparency of the atmosphere, and many other causes. While Dr. Draper was working upon the Orion nebula in America, Dr. Janssen was experimenting at Meudon with a view of determining the influence of some of the variable conditions upon the results obtained (*Comptes rendus*, vol. xcii. p. 261, 1881). By taking photographs with exposures of five, ten, and fifteen minutes respectively, the eminent French investigator found that the longer the nebulous light was beating upon the sensitive film, the greater was the extent of nebulosity portrayed. It was this fact which permitted Dr. Draper to obtain his epoch-making picture, and has led to even more remarkable results during the past few years.

So long ago as 1874, Dr. A. A. Common was engaged in celestial photography, but it was not until May 1882 that he exhibited a photograph of the nebula in Orion (*Monthly Notices, R.A.S.*, vol. xliv. p. 222, 1883-84). The instrument used by him was a reflecting telescope three feet in diameter, specially constructed for photographic work. Such a large instrument is necessarily difficult to adjust and drive, and a laborious series of experiments had to be made before it could be said to be in working order. But the time spent in devising improvements was well repaid by the photograph of the Orion nebula taken by Dr. Common in January 1883. The photograph showed details of the nebula never before properly represented by the hand, and which can hardly be discerned by the eye. With the confidence that comes from experience, it was then predicted that "we are approaching a time when photography will give us the means of recording in its own inimitable way the shape of the nebula and the relative brightness of the different parts, in a better manner than the most careful hand-drawings."

This prophecy was strikingly fulfilled in less than three years after it was made.

THE PLEIADES NEBULA.

In the early part of the year 1885 a fine photographic telescope was added to the equipment of the Paris Observatory, and placed under the control of two brothers, MM. Paul and Prosper Henry. The instrument had only been mounted a few months when it was used to photograph a cluster of stars—the Pleiades—which has attracted attention from time immemorial. The picture obtained showed truthfully the relative positions and grandeurs of the stars in and near the beautiful bunch of lucid points to which the telescope had been directed. But it was not so much the imprints of hundreds of stars that made the picture interesting to astronomers, as the fact that a new nebula appeared upon it. Round "stately Maia"—a star just visible to the naked eye—several wisps of nebulosity were clearly portrayed. Three further photographs of the same celestial region confirmed the existence of this nebulous matter, though no trace of haziness had previously been detected by ordinary telescopic observation (*Monthly Notices, R.A.S.*, vol. xlvi. p. 98, 1885-86).

It is a remarkable fact, however, that when an object has been discovered an observer is frequently able to see it, though he may have passed it over many times in previous surveys. So it was with the nebula round Maia. Very shortly after the announcement of the discovery had been made, M. Struve turned the 30-inch refractor at Pulkova towards the star to which attention had been directed, and found that he could distinctly see the nebulous surroundings (*Comptes rendus*, vol. cii. p. 281, 1886).

But faint objects are not only overlooked by the observer while viewing celestial scenery through his "optic tube"; they often go undetected on photographs themselves. The announcement of the discovery of the nebula recalled to Prof. E. C. Pickering's mind that certain irregularities had been noticed in a photograph of the Pleiades taken at Harvard College Observatory on November 3, 1885 (*Astronomische Nachrichten*, vol. cxiii. p. 399, 1886), that is, thirteen days before the MM. Henry obtained their first photograph showing Maia's nebulous surroundings. A re-examination of the Harvard College picture confirmed his surmise that the markings, which had previously been passed over as blemishes, were really the wisps of nebulosity photographed at Paris. Extending the scrutiny to the remainder of the Pleiades, indications of nebulous light were found about Merope, and a strange narrow streak was seen projecting from Electra. The Paris photographs showed similar appendages to these stars. This was not, however, a new discovery; the nebula near Merope was seen by W. Tempel while observing at Venice as far back as 1859 (*ibid.*, vol. liv. p. 286, 1861), and though several astronomers unsuccessfully searched for the object, many illustrious observers had attested to its existence (*Monthly Notices, R.A.S.*, xl. p. 622, 1879-80). Photography established the reality of Tempel's observations; and what is more, it was soon able to show that the faint patch, which had been the subject of so much discussion, was but a bright part of a vast nebulosity, in which the clustering stars were immersed.

Dr. Isaac Roberts was the astronomer who brought to light

the wonderful extensions round the Pleiades. His work in celestial photography has been so fruitful in results, that a brief record of its growth will not be out of place. In 1883, Dr. Roberts made a series of experiments to test the suitability of ordinary photographic lenses for the delineation of celestial objects ("Photographs of Stars, Star-Clusters, and Nebula," I. Roberts, 1894). The results were so promising that he determined to develop the photographic method of observation, and, with this end in view, he ordered to be constructed a reflecting telescope of twenty inches diameter, and one hundred inches focal length. The instrument was ready for use in April 1885, and work was then commenced with it. But it was not until more than a year later that its performances began to reach Dr. Roberts's expectations. Only those who have had to coax astronomical instruments into a tractable condition, can understand and appreciate the difficulties with which he had to contend. It was found that satisfactory photographs could not be obtained until the driving-clock of the telescope had been greatly improved in regard to its ability to keep the instrument accurately following the apparent movements of the stars. When a sensitive plate has to be exposed to starlight for three or four hours, the beams from individual stars must continually beat upon the same spot, otherwise the stellar images do not appear as circular discs upon the resulting picture. To attain this desideratum—that is to say, to make a clock capable of driving a telescope so

FIG. 1.—The Pleiades Nebula. (From a photograph by Dr. Roberts, with an exposure of ten hours.)

as to keep absolutely the same time as the stars—taxes the instrument-maker to his utmost; and, when Dr. Roberts commenced his work, there was no controlling clock that completely supplied the want. His early photographs, therefore, did not exhibit the stars as perfectly circular spots, nevertheless they greatly extended the state of knowledge of the Pleiades nebulosities. In October 1886, the first of his remarkable long-exposure photographs was obtained, the sensitive plate being kept directed to the Pleiades for three hours. With regard to the amount of nebulosity shown, the resulting picture was far in advance of all previous ones. It demonstrated that the MM. Henry had merely picked up the fringe of the nebulous matter round the Pleiades, for not only were all the stars of the cluster shown to be shrouded in nebulæ, but, to quote Dr. Roberts's words (*Monthly Notices, R.A.S.*, vol. xlvii. p. 24, 1886-7), "the nebulosity extends in streamers and fleecy masses, till it seems almost to fill the spaces between the stars, and to extend far beyond them. It suggests the probability that these stars in the Pleiades, together with many of the stars around them, are involved either directly or else in slight alignment with one vast nebula." This surmise was more than justified by future results. A year after it was made, the Henrys succeeded in obtaining a photograph which confirmed it. They, like Dr. Roberts, had been working towards perfecting their new engine of research. By the use of more sensitive plates, and by increasing the duration of exposure, they were able to bear witness that the feeble traces of nebulosity shown around the stars Maia, Merope, and Electra, on the views taken two years previously, appeared on the new photographs as bright nebulous masses, all more or less merging into one another, while an extensive lucid patch surrounded Alcyone (Observatoire de Paris, *Rapport Annuel*, 1887). Threads of nebulosity were also revealed, projecting from the central mass and having stars strung upon them like beads on a rosary.

Until recently, the best result of Pleiades photography was reached by Dr. Roberts at the end of 1888 (*Monthly Notices, R.A.S.*, vol. xlix. p. 120, 1888-89). The view of the wonderful group then obtained was produced by exposing the sensitive plate for four hours. It showed more clearly and more beautifully the filmy sea in which the stars are immersed, but did not extend the limits defined by the earlier pictures. The *ne plus ultra* of Pleiades photography was lately obtained by Dr. Roberts with an exposure of ten hours, and a reproduction of the picture is here given (Fig. 1). No process of reproduction can, however, do justice to the brilliant picture which Dr. Roberts has permitted us to reproduce.

The epoch-making views of the Pleiades obtained ten years ago gave a great impetus to nebular photography. The thought that for a time to be reckoned in æons, the gauze-like veil on which the Pleiades were studded had been unable to affect man's visual perceptions, but could register its existence automatically upon a prepared surface, was sufficient to open up a vista of marvellous possibilities.

Dr. Roberts's photograph of the Pleiades nebula has become a classic. Of his numerous other photographs of nebulæ, three have attained a like eminence; they represent the Great Nebula in Orion (to which reference has previously been made), the Great Nebula in Andromeda, and the Spiral Nebula in the constellation of Canes Venatici, and to these attention must here be confined. It is perhaps invidious to select these pictures from the collection of five hundred photographs of nebulæ and clusters with which Dr. Roberts has enriched astronomy, for every one of his photographs adds to what was previously known about the objects portrayed. The nebulæ above designated, however, were all made to record their own forms at about the same time, and each of the monochromes produced exhibited striking novelties.

THE ORION NEBULA.

A photograph of the Orion nebula taken by Dr. Roberts in November 1887, though only representing a tentative result, showed nebulous matter covering an area quite seven times greater than that covered by Dr. Common's photograph (*Monthly Notices, R.A.S.*, vol. xlvii. p. 89).

What Dr. Roberts had gained in extent, however, he had lost in detail. The delicate structure of the central part of the nebula appeared but a splash of white upon the print presented to the Royal Astronomical Society, though it is fair to add that they could be distinguished upon the negative. The lesson learned was, that it was extremely difficult to obtain upon one and the same print a representation of the nebula showing it to the fullest extent, and also exhibiting the fine markings and imperceptible gradations that characterise such objects. An increase of the time of exposure certainly increases the area of nebulosity depicted upon a photographic plate; but while the picture is having its limits extended, the filmy rays in the brighter regions of nebulosity are being "burnt out" by the cumulative action. This difficulty has now been overcome; for since Dr. Roberts revealed to astronomers the vast extent of the Orion nebula, he has taken, upon a single plate, photographs which show the fine detail of the nebulous structure as well as the great sky-area covered by the nebulous mass. One of these pictures, taken with a dual exposure of seven hours thirty-five minutes, on two evenings in February 1894, is here reproduced (Fig. 2), and it represents, according to Dr. Roberts, "the maximum of extent and detail that can be shown by aid of photographic methods." The illustration is, however, but a feeble representation of the original picture. Longer exposure with a reflecting telescope, such as that used by Dr. Roberts, would result in the photographic plate being fogged by the general luminosity of the sky sufficiently to obscure dim nebulous streamers and faint stars. With a refracting telescope Dr. Gill has given an ex-

posure of nearly twenty-five hours to the nebulous region around Eta Argus, without the film of the photographic plate being much darkened, but the conditions with a refractor are not precisely similar to those which obtain in the case of a reflector having a short ratio of focal length to aperture.

It appears, however, from some photographs recently taken by Mr. W. E. Wilson, F.R.S., and exhibited at the Royal Astronomical Society, that the time of exposure needed by the photographic plate to depict the greater part of the Orion nebula may be considerably reduced. Mr. Wilson uses a reflecting telescope of twenty-four inches aperture, and ten feet six inches focal length, constructed by Sir Howard Grubb, and provided with his usual type of driving-clock and electrical control. With this instrument, and an exposure of only forty minutes, he has been able to produce a portrait of Orion's great nebula which, as regards structural detail, will bear comparison with any previously obtained. Good photographs of the Orion nebula and other nebulæ have also lately been taken at the Paris Observatory with exposures of an hour or less (see p. 374). A comparison of Mr. Wilson's photograph of the Orion nebula with one recently taken by Dr. Roberts with the same exposure shows that they both contain about the same amount of detail and extent of nebulosity, so the decrease of the time of exposure is

FIG. 2.—Great Nebula in Orion. (From a photograph obtained by Dr. Roberts, with an exposure of 7½ hours.)

probably to be accounted for by the use of more sensitive plates than were formerly available. The central part of the Orion nebula, as photographed in forty minutes, is here reproduced by the side of a well-known drawing of the nebula lithographed by Mr. L. Trouvelot in 1864, from drawings made by Prof. G. P. Bond, of the Harvard College Observatory (Fig. 3). We have thus what is undoubtedly the best drawing of the nebula compared with a good photograph on the same scale (Fig. 4), and though much of the fine detail in the latter picture has been lost in reproduction, the difference between the work of the hand and that of the photographic plate is very striking.

Prof. Bond had to use every available hour for about five years in order to determine accurately the structure and distribution of the parts of the nebula. Such devoted perseverance cannot but command admiration, yet, except for the satisfaction which the celestial draughtsman derives from his work, a like expenditure of time and energy would now be almost useless. It is not, however, for the celestial photographer to depreciate the labours of the plodding observer. As Dr. Roberts himself has said, "we ought, with all gratitude, to admire the patient, long-suffering endurance of those martyrs to science, who, during the freezing nights of many successive winters plotted, with pencil in benumbed fingers, the crude outlines which have been handed down to us as correct drawings of this wonderful nebula, which we can now depict during four hours of clear sky with far greater accuracy than is possible by the best hand-work in a life-time" (*Monthly Notices, R.A.S.*, vol. xlix. p. 297, 1888–89).

THE SPIRAL NEBULA IN CANES VENATICI.

The years 1888–89 will be marked with a white stone in the annals of celestial photography, for it was then that so many remarkable proofs of its great capabilities were presented to the astronomical world. A photograph of the wonderful spiral nebula in the constellation Canes Venatici was obtained

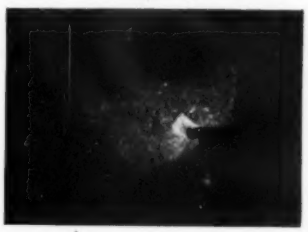


FIG. 3.—Bond's drawing of the Great Nebula in Orion (1859–63).

by Herr von Gothard in 1888 (*Astronomische Nachrichten*, No. 2854, 1888), and by Dr. Roberts in April, 1889 (*Monthly Notices, R.A.S.*, vol. xlix. p. 389, 1888–89). Dr. Common appears to have taken a good photograph of the nebula in 1883, but he did not publish any description of it at the time (*Observatory*, vol. xi. p. 393, 1888). An accurate picture of the object was certainly much needed. The nebula had been drawn by Herschel, Rosse, Lassell, and numerous other astronomers, and its convolutions had been more or less symmetrically traced. But so long as only drawings, differing widely from one another, existed of the spiral nebula in Canes Venatici, little was learned about the physical nature of the object. The photographs

FIG. 4.—Photograph of the Great Nebula in Orion, obtained with an exposure of forty minutes.

showed that the whorls of nebulosity were knotted with bright spots—stars in the course of formation—and these followed so closely the trend of the streams of nebulous matter, that their connection with it was placed beyond the possibility of doubt. The picture is a striking view of a stage of progress in the evolution of stellar systems; it exhibits in a most unmistakable manner a "fluid haze of light" eddying into worlds, and enables us almost to see cosmic processes at work. In the accompanying illustration the nebula, as observed with Lord Rosse's six-foot telescope and drawn by hand, is represented (Fig. 5) side by side, and on the same scale, as a photograph of the object obtained by Mr. Wilson with an exposure of forty

minutes (Fig. 6) Considered as pictures, the drawing is perhaps more attractive than the photograph, but this is because the photograph has been enlarged to such an extent that the grain of the film is shown. The comparison should be made between the original negative and the drawing, in order to be able to appreciate fully the assistance given by photography to the delineation of the structure of the nebula.

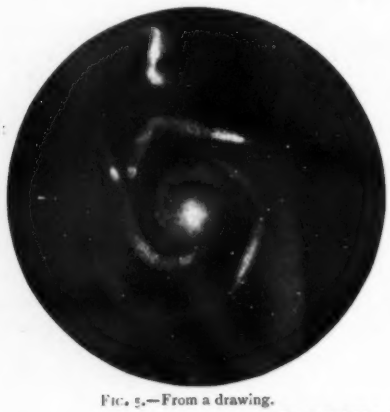


FIG. 5.—From a drawing.

FIG. 6.—From an enlarged photograph by Mr. W. E. Wilson.

The Spiral Nebula in Canes Venatici.

THE ANDROMEDA NEBULA.

Until Dr. Roberts took the photograph of the nebula of Andromeda in 1888 (*Monthly Notices R.A.S.*, vol. xlix. p. 65, 1888-89), astronomers did not understand that this object was a remarkable example of the ring-stage in celestial evolution. Bond's drawing (Fig. 7) was acknowledged to be the finest representation of the nebula, but how much it is inferior to the photograph (Fig. 8) is shown in the accompanying comparison of the two. It will be seen that the major axis of the small nebula near the top on the right has a different relative position in the two pictures, when considered with reference to the great nebula. The difference may indicate a change in the direction of the axis between 1847, when the drawing was made, and now, but it would be unwise to conclude that this difference is real, seeing that the distinct statement is made that "the lithograph represents somewhat inaccurately the relative positions of the chief nebulous centres of condensation" (*Annals of Harvard College Observatory*, 1876). But though this possible change is important in itself, it is not so instructive as the rings of nebulosity seen surrounding the bright central portion of the great nebula on the photograph. The dark lanes drawn by Bond are seen upon the photograph to be divisions between the zones of nebulous matter; and what visually appears to be accidental and enigmatical vacuities, are shown photographically to be the consequences of cosmogonical action. The hypothesis of the formation of worlds from nebulæ was thus confirmed, if not demonstrated, by the discovery of this new link to connect celestial species.

FIG. 7.—The Andromeda Nebula. (From a drawing by Bond and Trouvelot.)

FIG. 8.—The Andromeda Nebula. (From a photograph obtained by Dr. Roberts, with an exposure of ninety minutes.)

THE PORTRAIT LENS IN NEBULAR PHOTOGRAPHY.

It was at one time supposed that large telescopes were necessary to obtain valuable pictures of celestial objects; but as the work went on, it was found that ungainly instruments were not at all essential, and that excellent results were given by instruments of very moderate dimensions. For photographing faint stars, where the images on the photographic plates are practically points, the aperture of the object-glass or mirror is almost the only factor to be taken into account in estimating efficiency; but for nebulæ, comets and similar celestial objects, the images of which cover sensible areas on the plates, the ratio of focal length to aperture is all-important, and the actual aperture is a secondary consideration.

Experience has shown that a lens constructed in the same way as a portrait lens for use in an ordinary camera, is really the best instrument for several branches of celestial photography. The lens must of course be mounted, so that it can be made to follow the motions of the celestial sphere, but in other respects the camera need not differ essentially from that used in the ordinary portrait studio. The advantage of the portrait lens over the photographic telescope is that the field of view is much greater—it is therefore able to take a broader view of things.

The telescopes used for the international star catalogue and chart may be taken as the standard instruments for *star* work. The aperture of the object glass is 13 inches, and the focal length, roughly, 130 inches (ratio 1 to 10), the effective field being a little over 2 degrees square (4 square degrees on the celestial sphere). A portrait lens of 6 inches aperture and 30 inches focus (the favourite size with those who use portrait lenses for celestial photography) has a ratio of aperture to focal length of 1 to 5, and an effective field of 15 degrees square (225 square degrees). In photographing a nebula, this portrait lens only requires about one-half the exposure necessary when the standard telescope is used, while the area covered is nearly forty times as great. It follows, therefore, that for an extended nebula covering over 100 square degrees on the celestial sphere—and such nebulæ exist, and have been photographed—the portrait lens can give in two hours a complete picture comparable, in area of sky covered, with a picture that would require twenty-five exposures of four hours each with the standard star telescope; and that, whereas the picture with the portrait lens would all be on one plate and taken with one exposure, that with the standard telescope would be a mosaic built up from at at least twenty-five plates taken at different times, and consequently under very various atmospheric and astronomical conditions.

During the past eight years or so, a large number of photographs of nebulæ and nebulosity have been obtained by means of portrait lenses; and year by year the work done, both in this and other branches of astronomical photography, has been admirably summarised by Mr. Albert Taylor in the *Photography Annual*. Every one interested in the progress of celestial portraiture should refer to these annual records of results, as we have had frequently to do in preparing the subjoined account of the use of the portrait lens in astronomical photography.

The great advantage of the portrait lens or doublet over the telescope was admirably brought out by Prof. W H. Pickering, who, using a small camera at Wilson's Peak, California, in 1889, obtained a photograph including on one plate the whole constellation of Orion. The great nebula in Orion was clearly shown, but the chief value of the photograph lies in the large number of detached nebulous patches shown, which appear to be part of an enormous zone of nebulosity encircling the great nebula, and practically covering the entire constellation. The existence of this great mass of nebulous matter, and its obvious connection with the well-known nebula in the sword-handle of Orion, would probably never even have been discovered with long-focus instruments with small photographic fields; yet with the portrait lens it is a comparatively easy object.

In 1890, Mr. H. C Russell, F R.S., obtained a large number of striking photographs of nebulæ and the Milky Way with a 6-inch Dallmeyer portrait lens attached to the mounting of his telescope. The pictures thus obtained show many details of structure which are quite invisible in the telescope. Exposures of between four and five hours brought to light many peculiarities of arrangement of stars in Nebecula Major and Minor—the Magellanic clouds—and showed that the whole of the former apparently detached portion of the Milky Way had the structure of a complex spiral nebula with two nuclei two degrees apart. The Nebecula Minor as portrayed by Mr. Russell's camera bears a resemblance to the well-known Dumb-bell nebula.

Following closely on Prof. W. H. Pickering's work in 1889, the greatest advances in the photography of nebulæ in 1891 were due to Prof. Barnard at the Lick Observatory, Dr. Max Wolf at Heidelberg, Mr. Russell at Sydney, and Dr. Archenhold at Helensee, each of these observers using ordinary portrait lenses.

Dr. Max Wolf, with a 2½-inch aplanatic lens of 7¾ inches focus, photographed in one hour all the nebulæ in the Pleiades obtained by the Brothers Henry at Paris with four hours' exposure with the 13-inch charting telescope; and afterwards using a 4-inch Vöigtlander Euryscopic lens and a 5-inch Kranz Euroscopic lens, Wolf obtained more extension of the great nebula in Orion in 4 hours than Dr. Roberts had obtained with 4½ hours' exposure with his 20-inch mirror. These same plates of Wolf amply confirmed Prof. W. H. Pickering's results, and revealed an enormous amount of new detail in the nebula around ζ Orionis.

Turning his attention to the constellation Cygnus on June 1, 1891, Dr. Wolf, by 3 hours' exposure with the 5-inch Kranz lens, discovered an enormous nebula full of the most complex structure, and connecting a number of bright stars with many fainter ones in the Milky Way (*Astr. Nach.*, 3048). Starting apparently from a central point, the nebula spreads out branches which curve and meet "fold on fold of nebulous matter surging over the sky" and "becoming notably compact and luminous in the immediate neighbourhood of γ Cygni." Some of these branches are 8° long, so that at least four plates would be required for one of them with a photographic telescope of standard size; but the portrait lens secures all on one plate, and their true relations to each other and to the involved stars become at once apparent.

The great feature of this photograph, and of many subsequent pictures, is the obvious connection between bright stars and fainter ones. It was formerly believed that the brightness of a star was to some extent a measure of its distance from us, but the photographs with portrait lenses effectively disposed of this idea. Stars of nearly first magnitude were found to be joined to stars of the eighteenth magnitude by wisps of nebula, and to obviously form part of the same system in the heavens. These stars, the brightest of which are about 4,000,000 times more luminous than the faintest, must be at practically the same distance from us, and their differences in brightness must be due to differences of size or physical condition, or both, and not to any differences in distance.

Another interesting result from the photographs was the proof of the connection of nebulæ with stars of the Wolf-Rayet type of spectrum—stars with bright lines in their spectra—which Sir Norman Lockyer classifies as stars only just condensed from nebulæ, and next in order of evolution. Dr. Roberts, with 3½ hours' exposure with the 20-inch mirror, could detect no nebulosity round these stars in Cygnus, but the portrait lenses with exposures extending up to 13½ hours, indicated that all these stars are nebulous.

This work of Wolf was supplemented by some splendid results obtained by Mr. Russell at Sydney Observatory about the same time. The lens used, a 6-inch Dallmeyer of 30 inches focus, gave, with three hours, as much extension of the great nebula round the star η Argus as the 13-inch charting telescope showed with twice that exposure, while the relations of the nebula to the surrounding stars were much better shown. Two long exposures with the same lens on those curious detached portions of the Milky Way in the southern heavens, known as the Nebeculæ Major and Minor, revealed a great amount of previously unknown nebulous matter, much of which would be very difficult to obtain with larger instruments.

Dr. Archenhold, at Helensee, recognising the true principles of photography of celestial objects of large size, had two lenses constructed by Busch, the ratio of aperture to focal length being 1 to 4·5 and 1 to 2·5 respectively. With these lenses he photographed a very striking and extensive nebula near ξ Persei on October 27, 1891, with 32½ minutes' exposure. This new nebula resembles in many respects the great nebula in Andromeda, but probably covers a much greater area of the sky. The great effectiveness of this special lens is shown by eye observations with a 12-inch telescope; for even with the photograph to indicate where to look for details, scarcely any trace of the nebula can be made out (*Astr. Nach.*, 3082). Dr. Scheiner, at Potsdam (*Astr. Nach.*, 3157), has photographed this great nebula with a 4-inch portrait lens, giving exposures up to six

hours. The spiral form is clearly shown, while the extent of the nebula is greatly increased.

Prof. E. E. Barnard, with the 6-inch Willard lens of 30 inches focus at the Lick Observatory, has enormously extended our knowledge of these great diffuse nebulosities. It is quite impossible in the limits of this article to deal with these in detail, but the extraordinary form of the nebula round 15 Monocerotis, the enormous diffuse nebulosities in the constellation Cepheus and round the Pleiades, the tremendous extensions of the Orion nebulæ shown in his numerous articles in *Astronomy and Astrophysics* and the *Astrophysical Journal* since 1893, are all magnificent examples of the use of the portrait lens in photographing nebulæ; and one can have no hesitation in saying that without the portrait lens we should still be in ignorance of many of these wonderful objects. But Barnard has gone beyond the portrait lens, and has used the lens of a cheap oil lantern, the effective aperture of which is about 1½ inches, the focal length being 3½ inches, ratio 1 to 2·3. This gives a field of 30 degrees practically flat, the scale of the photographs being 10·3 degrees to 1 inch on the plate. Twenty photographs in October 1894 (*Astronomy and Astrophysics*, vol. xiii. p. 811) fully brought out the value of this instrument. One hour's exposure gave all the Andromeda nebula; thirty minutes gave all the diffuse nebulosity round the Pleiades photographed by Archenhold in four hours, and by Barnard with the Willard lens in three hours. The most valuable of all results, however, were those with Orion, obtained on October 3 and 28, 1894, with exposures of 2h. and 1h. 15m. The extensive spiral detected by Pickering in 1889 is fully shown in correct proportion, and "no description can give any idea of the form and magnitude of this nebula." Extending over 17 degrees in length and nearly the same in breadth it includes almost all the stars of the constellation, and forms in fact a robe for the body of the giant. The well-known "great nebula of Orion" is but a pigmy compared with the greater nebula revealed by Prof. Barnard's plates, and it is not too much to believe that longer exposure will probably fill the whole constellation with nebulosity, and show that the great nebula is simply the inner termination and the brightest part of the enormous spiral.

An English amateur, Dr. E. M. Sheldon (*Journal of the British Astronomical Association*, vol. v. p. 397), using a lantern lens similar to that used by Prof. Barnard, photographed this enormous spiral in Orion with 1¼ hours' exposure, in February 1895. Four hours on the constellation Cygnus with this lens gave all the nebulæ on Wolf's photograph taken with 13 hours' exposure.

The nebulosities in the Pleiades have attracted great attention since they were first photographed by the Brothers Henry at Paris in 1885. These nebulæ have always been remarkable from their intimate relations with individual stars in the cluster —"Maia is a diamond clasp on a curving plume, Electra extends a tentacle towards Alcyone, while Merope has a sweeping gauze trail and probably a nebulous satellite." In striking contrast to this we usually have in other regions of the sky stars and nebulæ intimately mixed, although frequently on recent photographs wisps of nebulæ are found joining stars, so that the structures appear to resemble festoons of pearls on a gauzy string. The most recent photographs of the Pleiades by Barnard at the Lick Observatory, taken 10h. 15m. exposure with the Willard (6-inch) lens; by Mr. H. C. Wilson, with a similar lens and 11 hours' exposure; and by Dr. Max Wolf, have revealed an enormous extension of the Pleiades nebulosity. The whole area is now 158 square degrees, and there are indications that even this is not the real limit, and that more prolonged exposures will give still greater extension, probably joining up the whole of the nebulosity into an enormous spiral similar to that covering the constellation Orion.

Other photographs exhibiting the same class of structure have been obtained of the region round Antares with 7½ hours' exposure by Prof. Barnard at the Lick Observatory. At first sight this new nebulous mass would easily be mistaken for the Pleiades Nebula, and it is a remarkable and very significant fact that both these masses and all other great nebulosities in the Milky Way either occupy vacancies amongst the stars, or are on the edges of such vacancies; and that in their immediate neighbourhood the stars exhibit long vacant lanes and other remarkable features, indicating that the nebula, stars, and vacant lanes are but different features of some vast and at present imperfectly comprehended system of celestial grouping.

The first results obtained by Prof. Bailey, at Arequipa, with the Bruce photographic telescope of the Harvard College Observatory have lately been recorded. This portrait lens, the largest in the world at present, has an aperture of 24 inches and a focal length of 135 inches, so that while the scale of the photographs is equal to that of the international star charts (1 minute of arc to 1 millimetre), the light-gathering power of the telescope is three times as great, and exposures with this instrument need be only about one-third of those required with the standard international telescopes to achieve the same results. But the Bruce telescope has a further advantage over the standard instruments. Its effective field is 25 square degrees (14-inch by 7-inch plates are used), whereas the effective field of the international instruments is only 4 square degrees in area. The daring experiment of Prof. Pickering in devising, and Mr. Alvan Clark in constructing, this enormous portrait lens has been completely successful (although several eminent astronomers on this side of the Atlantic doubted whether such an instrument could be constructed), and as a result we have an instrument which can do all the international work on less than 4000 plates and with very much reduced exposure. Prof. Pickering does not at present intend to duplicate the work of constructing the photographic chart of the stars, but will confine the instrument to nebulæ and special regions of the sky, and, with the aid of a 24-inch object prism, to spectrum photography. The published preliminary results are of very great value.

This article ought not to be concluded without mention of the fact that more than one astronomical photographer is of the opinion that some of the nebulosity shown upon pictures obtained with small portrait lenses is not real, but due to diffused starlight. A warm controversy has taken place with reference to this point, but this is not the place to present the views of the two parties. It has been shown in this article that large instruments, such as those used for the International Chart, with long focal length but restricted fields, can give us pictures full of delicate details of bright nebulæ, and these photographs are of extreme value; but we must look to the portrait lens for the larger details and for the fainter nebulosities which are absolutely beyond the reach of any photographic object-glass or mirror. There can be no rivalry between the two classes of instruments; each is perfect in its way, each will mislead if solely relied upon. Photographs of the same nebulæ, both with long focus object-glasses or mirrors and with portrait lenses, are necessary, and must be used to supplement each other, if we are to get correct ideas of the phenomena of stellar distribution and the connections between nebulæ and stars. The "best instrument to use" is not a matter of personal experience nor of individual opinion: the optical and photographic laws bearing on the subject are well known, and the practical limits of atmospheric definition and instrumental construction are within sight. The ideal instrument for photographing nebulæ will probably combine large aperture, short focal length, and the large flat field of the portrait lens; will be, in fact, a glorified portrait lens: there are optical reasons why neither the object-glass nor the mirror can be wholly satisfactory. While waiting for this instrument, every possessor of an ordinary rectilinear lens with an ordinary camera can, by strapping his camera on to an equatorially mounted telescope and using infinite patience, materially advance our knowledge of nebulæ by means of photography.

R. A. GREGORY.

PHOTO-MICROGRAPHY WITH HIGH POWERS.

PHOTO-MICROGRAPHY has for some years past advanced but slowly, although its present status as a means of delineating minute structure is undoubtedly much higher than it has ever been. In optical appliances the improvements have been many, the most notable being the introduction of apochromatic objectives. Their greater aperture and freedom from effects of the secondary spectrum have combined to render it possible to obtain good results with much greater ease than formerly. Some of the photomicrographs obtained, however, in the early days of microscopy are even now hardly excelled, although they were produced at the cost of enormous labour, and required extraordinary skill on the part of the operator, with the apparatus then available. The production of satisfactory photographs, when the magnification exceeds one thousand diameters, has always been a matter of some difficulty. One of the greatest of these has been the want of a source of illumina-

tion which should be of sufficient intensity without a considerable increase in the size of the illluminating surface. Various attempts have been made to adapt the oxy-hydrogen light for the purpose; but there always remains the objection, that however small the incandescent portion of the lime may be, it does

FIG. 1.—Surface markings on Podura scale. Photographed with Swift's 1/12-inch apochromatic, projection ocular 2, and central cone. Magnification, 2500 diameters.

not emit light of equal intensity over the whole of its surface. This can at once be seen if an image of the lime be projected on to a screen. The result is uneven illumination, a defect so often seen in high-power photographs, when the image of the radiant

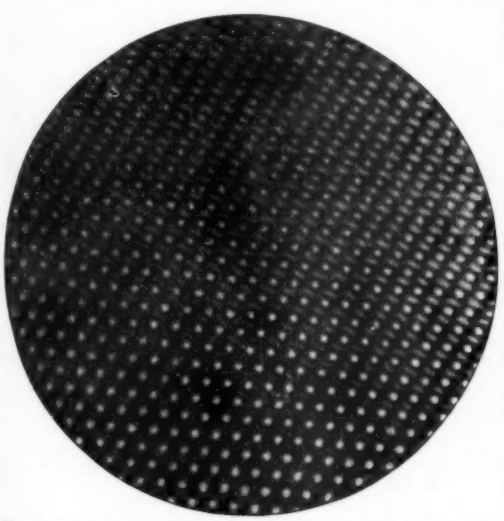


FIG. 2.—*Pleurosigma angulatum*. Photographed with Winkel's 1/20-inch homogeneous immersion, projection ocular 4. Central cone and malachite-green screen. Magnification, 500 diameters.

is projected by the achromatic condenser across the object, or what is known as "critical illumination."

The electric arc is the light which approaches most nearly to an ideal illuminant. The source of light is extremely small, but the intensity is great, and the incandescent surface is, if working under proper conditions, homogeneous. It has until recently been impossible to so control the arc that these conditions could be obtained with certainty. In all forms of lamp, whether hand-fed or automatic, the difficulty has been to maintain a constant position and condition of the crater on the positive carbon. This can be done by having a simple form of hand-feed apparatus with a pin-hole camera attached, through which an image of the carbon points is projected on to a ground-glass screen. Reference lines are provided on this screen, so that the length of arc and position of the positive crater can be continuously observed. The arrangement was exhibited at the two conversazioni of the Royal Society last year, and has been fully described before the Royal Microscopical Society. With such a form of arc-lamp absolute centration of the light can be secured and maintained without reference to the microscope, after the necessary position of the image of the arc on the screen of the pin-hole camera has been once obtained. The accompanying illustrations have been reproduced from photographs taken with the arc-light so arranged. Fig. 1 shows the surface markings on a Podura scale, magnified 2500 diameters. Fig. 2 is a frustule of *Pleurosigma angulatum*, magnified 5000 diameters. In neither photograph is there the slightest sign of de-centration, and in both cases centration was maintained entirely without reference to the microscopic image.

J. EDWIN BARNARD.
THOMAS A. B. CARVER.

A METHOD OF MEASURING WIND PRESSURE.[1]

THERE are few physical problems of greater immediate and obvious practical importance, than that involved in the measurement of air pressures under complex conditions of motion, and there are few problems which present greater difficulty, or—what is worse—uncertainty. It may be comparatively easy to obtain under any particular set of circumstances evidences of barometric variation by means of some indicating instrument, apparently suitable for the particular purpose, but it is a very different matter to decide how far the quantitative result is unaffected by actions set up by the instrument itself. Thus the record of the pressure plate gives information which is of little, if any, value in relation to the distribution of pressure over a large building; while the barometer itself is capable of giving misleading indications, whether it is too effectually protected from external influences, or too much exposed.

For measuring the wind pressure at any point of a structure of considerable size, a receiver or collector is required, with a convenient gauge connected by a tube. It is essential that the collector should not itself give rise to compressions or rarefactions affecting the gauge. To the invention of such an instrument Prof. F. E. Nipher has devoted much attention, and his final apparatus seems to fulfil its purpose admirably. Two equal thin metal discs, 2·5 inches in diameter, having bevelled rims, are screwed together, so as to leave a small space between, into which a connecting tube is passed through the centre of one of the discs. The end of the tube is flush with the inner surface, and the interspace is filled up with a certain number of layers of fine wire screen, which project at least half an inch beyond the edges of the metal discs. When this simple device is placed in a stream of air, it is found that the effects of rarefaction and compression, set up at different parts of the porous screen, completely neutralise each other, so that the pressure at the mouth of the tube is the same as the true intrinsic pressure of the external air. This property of the collector was severely tested by thrusting it out of a carriage window in a train which was travelling at the rate of sixty miles an hour: no effect on the gauge could be noticed, although the instrument was sufficiently sensitive to show instantly the effect of placing the hand at a tangent to the edge. The gauge which Prof. Nipher employed was a water manometer consisting of a cylindrical vessel partly filled with water, with a straight glass tube leading out from the bottom and inclined at 5 in 100 to the horizontal. The open end of this tube was in communication with a collector of the form suggested by Abbe[2] so as to secure a standard pressure of comparison.

[1] "A Method of Measuring the Pressure at any Point of a Structure, due to Wind blowing against that Structure." By Francis E. Nipher. (*Transactions* of the Academy of Science of St. Louis, vol. viii. No. 1.)
[2] Report of the Chief Signal Officer, 1887, 2, 144.

Being now satisfied with the trustworthy nature of his apparatus, Prof. Nipher determined to apply it to the determination of the distribution of pressure over a large pressure board. For this purpose the board, which was a wooden one, 4 feet long by 3 feet wide, was mounted on the roof of a railway carriage. It was bolted to a vertical iron pipe, and the couple required to keep it perpendicular to the direction of the wind was measured by a spring balance. On opposite sides of the board, and at the centre of one of the 108 4-inch squares into which the board was divided, two disc collectors were fixed and connected by rubber tubes with their respective gauges. The latter, together with a third, which was used as a level, were mounted on a board which was rigidly attached to a heavy pendulum within the carriage. The speed of the train varied generally between twenty and fifty miles an hour, and was checked by direct observations.

The total action on the board is the result of an increase of pressure in front and a decrease behind. Both the increase and the decrease are shown by this series of experiments to be proportional to the force necessary to hold the board to the wind as indicated by the spring balance. Further, the force measured in this way differs from that deduced from the data given by the collectors by no more than 1 per cent., and although this may be in a measure accidental, it affords a confirmation of the accuracy of Prof. Nipher's method. On both sides of the board the difference from the ordinary pressure becomes less as the periphery is approached, although there is some evidence of a minimum excess at the centre of the front face. Prof. Nipher gives a few notes on the application of the device to the study of pressure variation around a building. It is to be hoped that such developments as this will be realised. At present it is too early to estimate the full importance of these researches as a contribution to the study of anemometry; but the idea is full of promise, and the simplicity of the apparatus is certainly a great point in its favour.

AN ENCHANTED MESA.[1]

THE pueblo of Acoma, in Western Central New Mexico, is the oldest settlement within the limits of the United States. Many of the walls that still stand on that beetling peñol were seen by Coronado during his marvellous journey in 1540, and even then they were centuries old.

The valley of Acoma has been described as "the Garden of the Gods multiplied by ten, and with ten equal but other wonders thrown in; plus a human interest, an archæological value, an atmosphere of romance and mystery"; and the comparison has not been overdrawn. Stretching away for miles lies a beautiful level plain clothed in grama and bound on every side by mesas of variegated sandstone rising precipitously from 300 to 400 feet, and relieved by minarets and pinnacles and domes and many other features of nature's architecture.

None of these great rock-tables is so precipitous, so awe-inspiring, and seemingly so out of place as the majestic isolated Katzímo or Enchanted Mesa, which rises 430 feet from the middle of the plain as if too proud to keep company with its fellows; and this was one of the many wonderful homesites of the Acomas during their wanderings from the mystic Shípäpu in the far north to their present lofty dwelling-place.

Native tradition, as distinguished from myth, when uninfluenced by Caucasian contact, may usually be relied on even to the extent of disproving or verifying that which purports to be historical testimony. The Acoma Indians have handed down from shaman to novitiate, from father to son, in true prescriptorial fashion for many generations, the story that Katzímo was once the home of their ancestors, but during a great convulsion of nature, at a time when most of the inhabitants were at work in their fields below, an immense rocky mass became freed from the friable wall of the cliff, destroying the only trail to the summit and leaving a few old women to perish on the inaccessible height. What more, then, could be necessary to enwrap the place for ever after in the mystery of enchantment?

This tradition was recorded in its native purity some twelve years ago by Mr. Charles F. Lummis, and the same story was repeated by Acoma lips to the present writer while conducting a reconnaissance of the pueblos in the autumn of 1895. During this visit, desiring to test the verity of the tradition, a trip was made to the base of Katzímo, where a careful examination of the talus (especially where it is piled high about the foot of the great south-western cleft (Fig. 1) up which the ancient pathway was reputed to have wound its course) was rewarded by the discovery of numerous fragments of pottery of very ancient type, some of which were decorated in a vitreous glaze, an art now lost to Pueblo potters. The talus at this point rises to a height of 224 feet above the plain, and therefore slightly more than half-way up the mesa side. It is composed largely of earth, which could have been deposited there in no other way whatsoever than by washing from the summit during periods of storm through many centuries. An examination of the trail to a point within 60 feet of the top exhibited traces of what were evidently the hand and foot holes that had once aided in the ascent of the ancient trail, (Fig. 2) as at Acoma to-day. Even then the indications of the former occupancy of the Enchanted Mesa were regarded as sufficient, and that another one of many native traditions had been verified by archæologic proof.

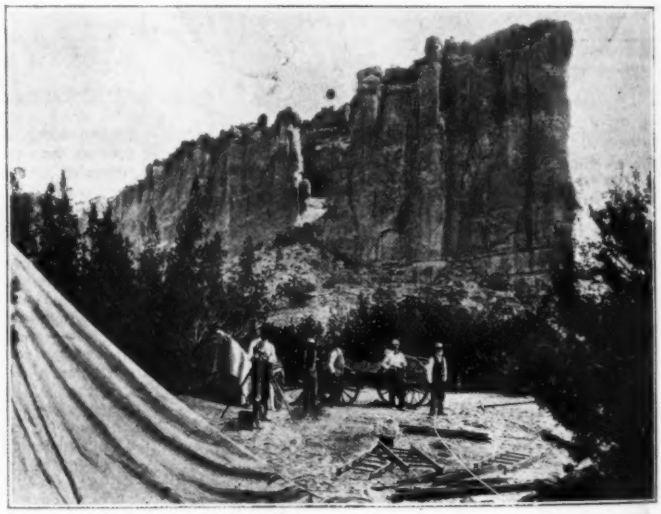


FIG. 1.—The Enchanted Mesa—the Great South-western Cleft and Talus Heap.

More recently the author visited Katzímo a second time, on this occasion with Major George H. Pradt, Mr. A. C. Vroman, and Mr. H. C. Hayt, in order to determine what additional data of an archæological nature might be gathered by an examination of the summit.

The ascent of the talus, in which the potsherds had been observed in such considerable quantities two years previously, was made in a few minutes, the ladders, ropes, and photographic and surveying instruments being carried with some effort, since climbing, heavily laden, at an altitude of 6000 feet, in a broiling sun, is no trifling labour; but the real work began when the beginning of the rocky slope of the cleft was reached. One member of the party, taking the lead, dragged the end of a rope to a convenient landing place, where a dwarf piñon finds sufficient nourishment from the storm-water and sand from above to eke out a precarious existence. Fastening the rope to the tree, the outfit was hauled up, and the other members of the party found a ready means of ascent. The next landing was several feet above, at the base of a rather steep pitch of about twelve feet. This wall, although somewhat difficult to scale,

[1] Abridged from a paper by Mr. F. W. Hodge, of the United States Bureau of American Ethnology, in the *National Geographic Magazine*.

may be climbed with greater or less safety by the aid of several small holes in its face. These holes were doubtless made artificially, but as the narrow pathway at this point is now a drainage course during periods of storm, the soft sandstone has become so much eroded that they have apparently lost their former shape.

The summit of Encantada was reached after some difficulty. It has been swept and carved and swept again by the winds and rains of centuries since the ancestors of the simple Acomas climbed the ladder-trail of which we found the traces. The pinnacled floor has not always appeared as it is to-day, for it was once thickly mantled by the sherd-strewn soil that now forms a goodly part of the great talus heaps below.

There is little wonder, then, that the party despaired of finding even a single relic when they had reached the top of the trail and looked about at the destruction wrought; and yet they had been on the summit only a few minutes when a sherd of pottery of very ancient type, much crackled by weathering, was found. This fragment is of plain grey ware, quite coarse in texture, with a dégraissant of white sand.

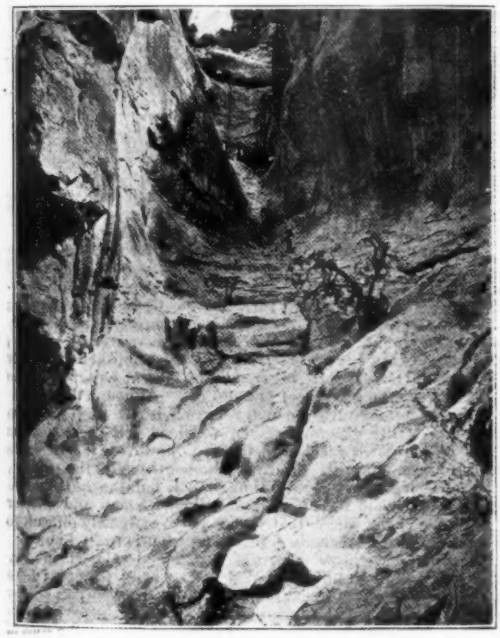


FIG. 2.—The Great Sandstone Cleft of the Mesa. Through this cleft the traditional trail passed, and distinct traces of it were found on each side of the vertical fissure to the right of the upper ladder.

During the twenty hours spent on the summit, every opportunity was taken of making a critical study of the general features of the top of Katzimo throughout the 2500 feet of its length, special consideration being devoted to the topography of the site, the erosion, the earthy deposits, the drainage, and the great cedars that stand gaunt and bare or lie prone and decaying because their means of subsistence have been so long washed away, and the party was forced to the conclusion that had house-walls, whether of stone or adobe, ever existed on the summit at a reasonably remote period, there was no possibility that any trace of them could have remained to this day. Nevertheless, the abundance of ancient relics in the talus, the distinct remains of the ladder-trail, the specimens found on the summit coupled with the destruction wrought by nature, the tradition itself—all testify to the former habitation of the site.

To the Acomas Katzimo is still enchanted, and as a subject in the study of mysticism the man of science must yet regard it. The law of a millennium is not undone by a few hours of iconoclasm.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—On March 15, Convocation will consider some alterations in the statute relating to the Aldrichian Demonstratorship in Comparative Anatomy, rendered vacant by the resignation of Dr. Blaxland Benham, who has been appointed Professor of Biology at Otago, New Zealand. Mr. Gilbert Bourne, of New College, has, in the meantime, been nominated as Lecturer in Comparative Anatomy, and his name will be submitted to Convocation on the same day.

Dr. Benham will be entertained at a farewell dinner by his colleagues on Friday.

The Junior Scientific Club met on Wednesday evening, March 9. Mr. A. W. S. Fisher read a paper on the salmon, and Mr. T. Annandale discussed the habits of British Amphibia. The officers for next term were elected. The Club proposes to hold its biennial conversazione next term, and arrangements are being pushed forward rapidly.

The cast of the skeleton of Iguanodon, which has been purchased by subscription, has now been set up in the court of the University Museum. Some valuable casts of other fossil reptiles have also been recently added to the collections.

CAMBRIDGE.—The honorary degree of Doctor of Science is to be conferred on Dr. Wilhelm Pfeffer, Professor of Botany in the University of Leipzig, and Croonian Lecturer at the Royal Society.

The Agricultural Examinations Syndicate report that ten candidates presented themselves for Part I., and nine for Part II. of the Examination for the diploma of the University. Six candidates were successful in both parts. The numbers show some increase on those of past years.

Regulations for the Gedge Prize in Physiology, taken in a broad sense, have been published. The prize will be given biennially for an original memoir or essay, and will consist of two years' interest on the capital sum of 1000*l*. Candidates must have worked in the University laboratories during six terms, and be of at least five, and at most seven, years' standing from matriculation.

The application for the recognition of St. Edmund's Hostel as a place of residence for students preparing for the secular priesthood of the Church of Rome, led to an animated discussion in the Senate on March 3. The weight of opinion was in favour of granting the application.

THE Senatus Academicus of the University of Edinburgh have resolved to offer the honorary degree of Doctor of Laws to Mr. Horace T. Brown, F.R.S.

PRESIDENT CHARLES DE GARMO, of Swarthmore College, Pa., has been elected to the professorship of the science and art of education at Cornell University, rendered vacant by the resignation of Prof. S. G. Williams; and Prof. Herbert Hibbard, of the University of Minnesota, has been elected assistant professor of mechanical engineering of railways and principa of the graduate school of railway, mechanical engineering.

NEARLY 55 per cent. of the net total of the Estimates for Civil Services, agreed to by the House of Commons on March 3, arises under the class of education, science and art, which shows a net increase of 457,094*l*. over the grants of last Session. To the total of the class—viz. 11,965,796*l*.—the three Public Education Estimates contribute 11,028,776*l*., being a net increase of 425,903*l*. The chief remaining increase is 22,663*l*. under the Science and Art Department Estimate (mainly for additional payments to science schools for attendance and on results). An important change has been effected in transferring to the Education Departments, England and Scotland, the grants, &c., for drawing in elementary schools, hitherto borne on the Science and Art Department's Vote, and in transferring to the Scotch Education Department the other Science and Art grants in Scotland.

A NOTEWORTHY feature of the little volume of announcements of classes held in the Northampton Institute, Clerkenwell, is a table of special courses adapted to various classes of students. By referring to this table, any young artisan can see what courses he ought to take to educate himself in the scientific principles of his trade. Similar guides to study, now often inserted in the prospectuses of technical institutes, are of great value in inducing students to take up systematic courses of instruction,

and the Northampton Institute has done well to adopt such a means of encouraging earnest work. The Lord Mayor and Sheriffs have consented to pay a State visit to the Institute on March 18, for the purpose of inspecting it and declaring it formally open. The buildings and equipment have up to the present cost over 80,000*l.*, and the expenditure upon the latter is not yet complete. In addition the land—over one and a quarter acres—generously given by the late Marquis of Northampton, is estimated to be worth not less than 25,000*l.* The Institute is a branch of the City Polytechnic, and is situated in one of the busiest parts of the metropolis immediately north of the City boundary.

FROM the sixth annual report of the Technical Instruction Committee of the City of Liverpool, we gather the following items:—The Committee clearly recognises that technical education is inseparably bound up with general secondary and higher education, and must be organised in vital connection therewith.—After some delay, a commencement has been made with the erection of the new Central Technical Schools. The cost of the erection of the building comprising the new schools and the museum extension will be nearly 90,000*l.*—The Committee remark that it would be more satisfactory if greater attention were paid to mensuration and other practical applications of elementary mathematics; since it is a frequent complaint, on the part of teachers of special technical classes, that their students come to them with too little mathematical knowledge and aptitude, and are often unable to grapple with even simple quantitative problems. This difficulty not only applies to Liverpool, but to technical classes in most parts of the country.—The co-operation of the University College with the educational work of the Committee is most satisfactory, and is of great assistance in the construction of an organised scheme of technical instruction.

THE London University Commission Bill was read a second time in the House of Lords on Friday last. In moving the second reading, the Duke of Devonshire pointed out that the measure was founded on the recommendations of the Royal Commission which reported in favour of the two functions of teaching and examining being combined in one University for London. The Bill is substantially the same as that which passed the House of Lords in the last Session of Parliament, but reached the House of Commons too late to be carried through all its stages. To provide against the occurrence of a similar difficulty, the Bill has been introduced earlier in the year than has hitherto been found possible; which gives grounds for the hope that it will take its place on the Statute-book before the close of the present Session. A very large part of the formidable opposition against the Bill has been removed by the introduction of certain modifications. These amendments are in the direction of restricting the power of any future Senate to alter the statutes or regulations made by the Statutory Commission in accordance with the provisions contained in the schedule of the present measure. "I cannot even now assert that opposition no longer exists," said the Duke of Devonshire, "but it is very difficult indeed to understand upon what grounds the measure can be opposed. I have endeavoured to show by what an overwhelming amount of scientific teaching, opinion, and experience it is supported, and I am utterly unable to discover any weight of opinion on the other side which can for a moment enter into competition with the expressions in its favour." Lord Herschell and Lord Reay warmly supported the Bill, which was then read a second time

AT the recent meeting of the Federated Institution of Mining Engineers, Prof. Henry Louis, Durham College of Science, Newcastle, read a paper on "Technical Education in Mining," which should be seen by all Technical Education Committees having mining classes. Prof. Louis made, at the outset, a broad distinction between the training suitable to the working miner or subordinate mine official, and that suitable to mining engineer or general manager. As regards the former he ought to leave his Board school in about the fifth standard, and commence receiving his technical instruction—a very different thing from technical education—underground, whilst continuing his scientific education in evening continuation and science schools. It is greatly to the discredit of the powerful and wealthy miners' unions of this country, that they make no attempt to provide the rising generation with scientific training bearing on their work, especially seeing that such training is the best possible safeguard against accident. For both working miners and engineers, the present legislation, that takes no account of time spent in learning the sciences underlying the art of mining, is most pernicious. Mining students ought to enter some mining college at the age of seventeen, and devote at least three years to learning first the pure and then the applied sciences that they will require in their profession, but none of the pure sciences need to be studied very profoundly. The systematic neglect of the study of dressing of minerals in this country has already had serious commercial results, *e.g.* at Nenthead, and its cultivation is urged. Prof. Louis suggests the introduction of the American system of "Summer Mining Schools" as a method worthy of trial for giving college students an insight into practical work, but points out that college work alone without practical experience is insufficient. On the very open question as to whether college work should precede or follow practical training, Prof. Louis holds the former to be probably the better plan. He concludes with the following recommendations. (1) Every manager of a mine, whether coal or metalliferous, to hold a certificate. (2) Examinations for certificates to be controlled by a central Board, and made uniform in conditions and character for the whole of Great Britain (and if possible for the Colonies also) (3) Residence in a recognised science college to count as part of term of apprenticeship, whilst not less than three years underground should also be insisted on. (4) Every mine surveyor to hold a certificate of proficiency.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, January 27.—"Mathematical Contributions to the Theory of Evolution. On the Law of Ancestral Heredity." By Karl Pearson, F.R.S., University College, London.

The Darwinian theory has for its main factor the perpetuation of favourable variations by natural selection under the law of heredity. Hence any complete quantitative treatment of evolution must deal (1) with the nature and distribution of variation; (2) with the nature and influence of selection, and this not only upon the selected but upon all correlated characters or organs; and (3) with the law of heredity. Earlier published and other written but unpublished papers of the present writer cover to some extent the ground of (1) and (2). Although the mathematical theory of variation and selection is yet very far from completion, the general lines on which it will proceed seem fairly clear. With the law of heredity, however, the case has hitherto been different. Much has been written on the subject, much has been attributed to inheritance, but the quantitative measurements and facts have formed such a small and slender proportion of the whole, that it has been extremely difficult to base a rounded mathematical theory on what is really known.

The very suggestive theory of heredity developed in Mr. Galton's "Natural Inheritance" has two main features: (*a*) a theory of regression, which states the average proportion of any character which will be inherited under any degree of relationship. This theory is very simple: if the average of the sons of any parent has w of the parent's deviation from the average parent, then the average grandson would have w^2 of the deviation, and so on. Collateral heredity is also determined, and for two brothers was found equal to $2w$. Mr. Galton's value of w was $\frac{1}{3}$.

(*b*) A law of ancestral heredity. According to this law the two parents contribute $\frac{1}{4}$, the four grandparents $\frac{1}{8}$, the eight great grandparents $\frac{1}{16}$, and so on, of the total heritage of the average offspring.

These two parts of the theory, however, are not in entire agreement.

The recent publication of Mr. Galton's remarkable paper on ancestral heredity in Bassett hounds has, however, led the writer to reconsider (*b*). If that law be true, then for every organ and for every grade of kinship the amount of heredity is numerically determinable. The solution of the problem of heredity is thrown back upon the solution of an infinite series of linear equations. Their solution gives results which seem to the writer in good agreement with all we at present know about the influence of heredity in various degrees of kinship. For example, fraternal is no longer *twice* filial regression, but has a value (0·4000) well in accordance with calculations of English stature and Indian cephalic index. In short, if we discard Mr. Galton's relations between the regressions for various grades of kinship, and start

solely from his law of ancestral heredity, the whole theory of heredity becomes simple, luminous, and well in accordance with such quantitative measurements as have so far been made.

It is possible to somewhat generalise the law of ancestral heredity. Modifying Mr. Galton's definition of midparent, a conception is formed of the mid-sth parent, a sort of mean of the ancestry in the sth generation, and the contribution of this mid-sth parent to the offspring is assumed to have a constant ratio to that of the mid-$(s + 1)$th parent, whatever be the value of s. With this simple law the whole of heredity is found to depend upon a single constant γ, termed the *coefficient of heredity*. γ may vary from organ to organ and from race to race. It may itself be subject to selection, if heredity be not looked upon as *à priori* given and antecedent to any evolution by natural selection. In Mr. Galton's statement of the law, $\gamma = 1$. This may really be the case, but it is not necessary to the theory, and it is not required by any facts as yet observed.

Given this simple law of ancestral heredity, there flow from it the following results :—

(1) Heredity between any grade of individual kinship.

(2) The value of the stability that results from any long or short process of selective breeding, and the variability of the breed so established.

(3) The law of cross heredity, *i.e.* the degree of relationship between two *different* organs in kindred.

(4) That panmixia without active reversal of natural selection does not lead to degeneration.

It may be of interest to add that since the law of ancestral heredity allows for the variability of each individual ancestor from the ancestral type, giving that variability its share in the heritage of the offspring, it is inconsistent with Weismann's theory of the germplasma. It does not, of course, answer one way or the other the question as to the inheritance of acquired characters.

Thus Galton's law of ancestral heredity leads to, what has not hitherto existed, a rounded and comprehensive theory of heredity. It describes with surprising closeness all facts so far quantitatively determined, and opens up a wide range of conclusions which await testing by fresh data. Should those data be in agreement with its predictions, then the law of ancestral heredity will in the future play as large a part in the theory of evolution as the law of gravitation has played in planetary theory. It is the quantitative basis on which Darwinism, the evolution of species by natural selection *combined with heredity*, will then be placed ; and at one stroke it will clear away a veritable jungle of semi-metaphysical speculations and hypotheses, and this for the simple reason that it is based upon quantitative observations and not on verbal subtleties. It will be difficult, perhaps, to make people realise that there is a science of heredity, simple and consistent, in existence ; yet even at the present time it is the number of observers and experimenters, rather than the science, which needs to be strengthened.

"The Magnetic Properties of almost pure Iron." By Ernest Wilson.

In the Siemens Laboratory, King's College, London, a series of experiments were carried out on a ring of iron containing only about ·12 per cent. impurities. The ring was tested as received and after careful annealing. As received, the magnetic hysteresis loss was slightly greater than in an exceptionally good sample of transformer plate examined by Ewing. After annealing the hysteresis loss was still slightly inferior to the Ewing specimen, but an exceptionally large value was obtained for its maximum permeability ; μ being 5490 for B = 9000 C.G.S. units per square centimetre. The coercive force for maximum B = 15,720 is 1·13 C.G.S. units. Further experiments were carried out to investigate the apparent magnetic instability of the specimen. The author finds that this effect cannot be accounted for by the self-induction of the ring, nor the time taken for the current to rise to its full value. A method is explained for testing the rapidity with which the current rises to its maximum value. The propagation of magnetism in the ring as affected by induced currents is dealt with, and it is pointed out that these may have an effect on the observations, although it is difficult to account for such times as five and ten seconds, unless the molecule itself be considered. It is deduced from the experiments that the amplitude of induction might not be so great for high frequency and small induction density, which would be of importance in the case of transformer cores if it existed. Reference is made to experiments with alternate currents which show no such diminution ; but it is pointed out that experiments with alternate currents would be difficult to carry out, on account of the necessary accurate control of the magnetising force.

"The Kelvin Quadrant Electrometer as a Wattmeter and Voltmeter." By Ernest Wilson.

Two of these instruments were available to the author when carrying out the series of tests described in this paper. He was thus able to use one in connection with a revolving contact-maker to determine the instantaneous rate at which work was being done by alternate currents while testing the other as a direct-reading wattmeter. The author finds that by the contact-maker method he gets good accuracy by taking ten positions of the contact-maker per half-period, and calculating directly from the figures without integrating the curves. When current and potential were in phase an agreement within 1 or 2 per cent. was obtained between the watts calculated this way and the product of the square root of mean square values given by an ammeter and voltmeter. The use of a small mallet for gently tapping the electrometer base is recommended to overcome the effects of viscosity of the acid in the electrometer when this is old, although in the new form of instrument the viscosity gives little or no trouble, since the sensibility is not so great. The wattmeter constant was determined for various frequencies, phase differences, amplitudes, wave forms, and the results show that the Kelvin quadrant electrometer can be used with accuracy as an alternate current wattmeter, but that it is necessary to make sure that within the range of potentials applied Maxwell's formula is verified. Two methods of doing this are explained. The author observed a potential of nearly half a volt, due to the revolving contact-maker alone, when directly placed across the electrometer ; but this inductive effect disappeared when a capacity, large compared to that of the instrument, was placed across it. The paper concludes with an interesting note on a manganin strip used for comparatively large currents. The experiments were carried out in the Siemens Laboratory, King's College, London.

February 3.—"The Pharmacology of Aconitine, Diacetylaconitine, Benzaconine and Aconine, considered in relation to their Chemical Constitution." By J. Theodore Cash, M.D., F.R.S., and Wyndham R. Dunstan, M.A., F.R.S.

In this research the pure alkaloids aconitine, benzaconine and aconine derived from *A. Napellus*, and an aconitine derivative, diacetylaconitine were examined with reference to their action upon warm- and cold-blooded animals, a similar series of experiments being made with each alkaloid for purposes of contrast.

It was found if the dose of aconitine, which is invariably lethal per kilo. body weight, be represented by the unit, that (in very general terms) diacetylaconitine would have $\frac{1}{10}$" of the toxicity of aconitine, benzaconine $\frac{1}{100}$, and aconine $\frac{1}{1000}$. There is, therefore, an enormous variation in toxicity amongst these alkaloids.

A few of the chief results obtained are here summarised.

Aconitine in small doses slows the pulse, whilst larger proportions not only accelerate but disturb the sequence of ventricles upon auricles—an independent rhythm being produced at one stage of action. The central vaso-motor apparatus is much more powerfully affected than the peripheral, great respiratory acceleration precedes slowing, which, according to the dose, may pass into failure. Sensory nerves are depressed in function, whilst motor-nerve terminations and skeletal muscle retain their activity, except when largely hyperlethal doses have been used.

Diacetylaconitine has less tendency to cause disturbance of sequence between auricles and ventricles ; but, apart from variations in this and other minor points, its action is in the main like that of aconitine.

Benzaconine alters the cardiac rhythm, the pulse becoming much slowed ; and at one phase of action the sequence of ventricle fails to every second auricular beat. Entire suspension of contraction may even occur, both auricles and ventricles, followed by spontaneous resumption of systole. Respiration is slowed from the first.

Sensory nerves are but little affected, whilst motor-nerve endings and, to a lesser degree, skeletal muscle show a reduced and curiously intermittent response to stimulation.

Aconine strengthens the cardiac systole, and is opposed to the dislocation of rhythm produced by aconitine, to which it therefore acts in a large measure as an antagonist and antidote. On motor-nerve termination it has a curare-like effect.

All the alkaloids examined reduce body temperature, though in varying degree.

In conclusion it is pointed out that, whilst the toxicity of aconitine mainly depends on the presence of the acetyl group, the introduction of two additional acetyl groups into the aconitine molecule does not materially alter the pharmacological action, but merely reduces the toxicity of the parent alkaloid. The *removal* of the acetyl group abolishes the stimulant action upon the respiratory centre and pulmonary vagus. It also favours reduced activity in motor, rather than in sensory nerve endings.

The benzoyl group—present in benzaconine, absent in aconine—causes a peculiar and distinct modification in the heart's action, associated with a disturbance of sequence never witnessed after aconine. The curare-like effect of aconine, and the intermittent failure of the stimulated benzaconine muscle, are also traceable to the modification in chemical constitution arising from the absence or presence of the benzoyl group.

Attention is drawn to the practical bearing of the fact that benzaconine and aconine, pharmacological antagonists of aconitine, occur with it in the root of *Aconitinum Napellus*, from which the medicinal preparations of the drug are made.

February 10.—"Contributions to the Theory of Alternating Currents." By W. G. Rhodes, M.Sc. (Vict.).

This paper was divided into two parts. Part I. dealt with a method of finding the steady values of alternating currents in any circuits or systems of circuits, without having to perform integrations of differential equations which may be somewhat complicated.

Part II. was devoted to the consideration of the effects of higher harmonics in E.M.F.s and currents on the values of the impedances and reactances of circuits.

Among other results it was shown that periodic E.M.F.s and corresponding currents can in all cases be represented by simple sine curves having the same root mean square values, and suitable phase positions depending on the time constants of the circuits and on the periodicities of the harmonics present.

February 17.—"On Artificial Temporary Colour-Blindness, with an Examination of the Colour-Sensations of 109 Persons." By George J. Burch, M.A.

By exposing the eye to bright sunlight in the focus of a burning-glass behind a red screen, a condition of temporary red-blindness is induced during which scarlet geraniums appear black and roses blue. Green-blindness and also violet-blindness may be produced by similar means.

The author has systematically investigated the appearance of the spectrum during the colour-blindness induced by exposure to intense light from various parts of the spectrum, and finds that the red from A to B, the green near E, the blue half-way between F and G, and the violet at and beyond H, produce well-defined and characteristic results, indicating that each of these colours corresponds to a definite colour-sensation.

In each case all direct sensation of the colour used for fatiguing the eye is lost, but the observer is conscious of a positive after-effect of the same colour, by which the hue of all other colours is modified. The temporary abolition of any one colour-sensation is without effect on the intensity of the remaining colour sensations. Any two, or any three, of the four colour sensations, red, green, blue, and violet, can be simultaneously or successively exhausted. The observed facts are, in the author's opinion, more in accordance with the Young-Helmholtz theory than with that of Hering, but they imply the existence of a fourth colour-sensation, namely blue.

Physical Society, Feb. 26.—Mr. Shelford Bidwell in the chair.—The meeting was held at Eton College. The President informed the Society of the resignation of one of its Hon. Secretaries: Mr. T. H. Blakesley, M.A. In doing so, he referred to the many important services rendered to the Society by Mr. Blakesley, and he expressed the Society's deep and general regret that Mr. Blakesley should now feel unable to continue them. The Council elected Mr. W. Watson to the office of Hon. Secretary.—Prof. T. C. Porter, in whose laboratory the meeting was held, said it gave him very great pleasure to welcome the Physical Society. Eton had been most properly called "the English home of ancient classical learning." For the education of youth, classics had proved themselves of cardinal value. He believed that other Fellows of the Physical Society, with himself, desired that this revered tradition of classics should be maintained at Eton; at the same time, they would agree with him that there was no better supplement to classics than a fair knowledge of the natural sciences. Prof. Porter then gave a lecture, illustrated by lantern photographs, on "Observations on the Peak of Tenerife." He also described his method for measuring the diameter of the earth. The method consists in observing the shadow cast by the Peak upon the sea, and measuring the time that elapses between the moment when the apex of the shadow touches the sea-horizon, and the instant when it is eclipsed by the shadow of night. Prof. Porter called attention to a phenomenon hitherto unnoticed, *i.e.* that the heated air ascending from the Peak casts a shadow, seen as a faint prolongation of that of the Peak; it rises obliquely from its apex. A photograph was exhibited, taken on a quarter-plate, in which is visible the curvature of the horizon as viewed from the altitude of the Peak. An interesting series of unique photographs, illustrating the conformation of the Peak and the phenomena of sunrise and twilight in that latitude, was also shown. In regard to twilight he noticed that the first approach of night, as observed looking eastward, is marked by a dark border of about five degrees width, followed by a sky somewhat lighter. The lecturer discussed also a new theory of geyser action. The theories of Bunsen and others fail to explain why the geyser-throat appears almost completely full at the end of an eruption. This immediate refilling is the more remarkable when it is remembered that some geysers of the Yellowstone region discharge a million and a half gallons at each eruption, and that the eruptions may occur at five-minute intervals. Moreover, the theories generally accepted assume steeper temperature-gradients than those in a region like Yellowstone. Prof. Porter suggests that the phenomena are better explained on the assumption of an arrangement of strata such as exists in artesian-well districts, the throat or shaft of the geyser being in the position of a well communicating with a subterranean stream—the "tube" of the geyser. From the disturbed nature of the region the tube of the geyser follows a waved course; the "shaft" rises from the crest of the terminal wave; the other crests may be steam-traps. Since a basin-like formation is characteristic of all geyser regions, it is fair to assume that the end of the tube remote from the shaft has an outcrop in the hills that form the sides of the basin. By means of this outcrop, water continually flows into the tube. When the tube does not sink deeply enough to attain the temperature necessary for the generation of steam, a quietly-flowing hot-spring is the result. But if, at any point, the tube descends to underground temperatures sufficiently great, steam is formed, and is trapped at the highest point of a bend. Ultimately this steam checks the flow of water, until the accumulated head of cool water from the hills overcomes the resistance, condenses the steam, and re-establishes liquid continuity. Urged by the pressure behind it, the stream is impelled towards the geyser throat; it forces the hot water before it until equilibrium is once again restored in the tube. Prof. Porter afterwards exhibited a method for viewing lantern projections in stereoscopic relief. A slotted disc rotates in front of two lanterns. These project two stereoscopic views in rapid alternation upon a screen, in such a way that the two projections are approximately superposed. In the rim of the disc, other slots are cut, through which the observer looks. The arrangement of slots is such that the right or left eye is only able to see the screen at the moment when its own picture (*i.e.* the picture from the right or left lantern) is on the screen. When the rotation is sufficiently rapid, the views appear as one, without "flicker," in stereoscopic relief.—The President proposed votes of thanks, and the meeting was adjourned until March 11.

Entomological Society, February 16.—Mr. G. H. Verrall, Vice-President, in the chair.—Mr. G. C. Champion exhibited specimens of *Isodermus gayi*, Spin., from the Straits of Magellan, and *I. planus*, Er., from Tasmania, both found by Mr. J. J. Walker. The genus, *Isoderma*, belonging to the Aradidæ, afforded an interesting case of geographical distribution, the only known species occurring in Chili, Australia and Tasmania.—Mr. C. O. Waterhouse referred to the similar distribution of other species of insects, which went to support the theory of a former connection between South America and Australia.—Mr. Champion also showed an example of *Bagous lutosus*, Gyll., from Sweden. This insect had been on the British list since the time of Stephens, but possibly in error, as all the examples he had seen in collections were wrongly so named.—Mr. Jacoby ex-

hibited a pair of the singular weevil, *Apoderus tenuissimus*, Pasc., from the Philippines.—Mr. Burr exhibited species of Orthoptera, of the family Eumastacidæ, resembling dead leaves. This was the only family of Acrydiidæ in which such resemblances were found.—Dr. Chapman exhibited a specimen of *Zygæna exulans* with six wings, the supernumerary pair arising between the normal left forewing, and the corresponding leg on the same side. The uppermost wing appeared normal in every respect, the second was a reduced copy of the basal half of a forewing, and the third a portion of crumpled wing-structure.—Mr. O. E. Janson exhibited a pale variety of the rare *Papilio mikado* taken in South Japan.—Mr. Tutt showed a variety of *Enodia hyperanthus*, taken by Mr. F. H. Day near Carlisle, and banded on the under-side like a *Canonympha*; also two moths from the same neighbourhood, which, after careful comparison, he regarded as females of *Hydrilla palustris*. This sex was almost, or quite, undiscovered in Great Britain, and the occurrence of the species so far from the fen-district was remarkable.—Mr. H. J. Elwes read a paper, entitled "A Further Revision of the Genus *Erebia*," which was illustrated by the exhibition of examples of every known species. Tracing the geographical distribution, he stated that the principal European centres of the genus were the Pyrenees, and especially the Alps, only a few forms occurring in Scandinavia, while the Ural Mountains and Caucasus were almost destitute of species. The genus became abundant in East Siberia, from which region the few North American forms appeared to have been derived.—Dr. Chapman also read a paper on the species of the genus *Erebia*, a revision based on the male appendages, illustrated with drawings of these organs in about sixty species.—In connection with the above papers Mr. Tutt exhibited and made remarks on long series of *Erebia nerine*, *E. glacialis*, *E. euryale*, *E. ligea*, &c., chiefly from the Alps.

PARIS.

Academy of Sciences, February 28.—M. Wolf in the chair.—Chemical action of the silent discharge: oxides of carbon and nitrogen, by M. Berthelot. A continuation of a previous paper. Mixtures of carbon monoxide and nitrogen, submitted to the prolonged action of the silent discharge, give only the sub-oxide C_4O_3, the nitrogen being unchanged. With excess of hydrogen, a condensation product of the empirical formula $(CH_2O)_n$ is produced. For carbon dioxide, six hours' action with hydrogen in excess caused the almost complete absorption of the oxide. With nitrogen in addition an amido-compound and some ammonium nitrite were formed.—Chemical action of the silent discharge: alcohols and etherial derivatives in presence of nitrogen, by M. Berthelot. The systems studied were mixtures of nitrogen with methyl alcohol, ethyl alcohol, normal propyl, isopropyl and allyl alcohols, phenol, pyrocatechol, resorcinol, hydroquinone, pyrogallol, glycol, and methyl and ethyl ethers.—Fuchsian functions and the equation $\Delta u = e^u$, by M. H. Poincaré.—On a particular case of the motion of liquids, by M. E. Fontaneau.—On the Euler transformation and the determination of singular points of a definite function by Taylor's development, by M. Ernst Lindelöf.—On an extension of Gauss's method of quadrature, by M. Henry Bourget.—On autocollimating telescopes, and an optical verifier of the lines and surfaces of machines, by M. Ch. Dévé. The arrangement described, which is illustrated by three diagrams, permits of the exact verification of the accuracy of plane surfaces, or of the parallelism of two surfaces.—Lines of force and equipotential surfaces in nature, by M. G. M. Stanoiévitch. The paper is illustrated by three plates showing the analogy between the lines of growth in plants and equipotential surfaces. The nodes in the wood play the part and produce the same disturbances in the cellular field as magnetic or electric poles in their respective fields.—On the properties and crystallisation of anhydrous barium sulphide, by M. A. Mourlot. The crystallised sulphide was obtained in two ways: by submitting amorphous barium sulphide, previously prepared by the action of hydrogen sulphide upon barium carbonate at a red heat, to the temperature of the electric furnace, and by heating directly in the electric furnace a mixture of barium sulphate and carbon in the exact proportions necessary to form the sulphide. In this way white crystals belonging to the cubic system were obtained, which behave toward chemical reagents like the amorphous form, except that the action is somewhat slower in the case of the crystals. The behaviour of the sulphide towards fluorine, oxygen, and oxidising agents, phosphorus oxychloride, and carbon was studied.—Action of carbon monoxide upon palladious chloride, by M. E. Finck. By the interaction of these two substances three compounds can be isolated, $COPdCl_2$, $C_2O_3PdCl_2$ and $C_2O_3Pd_2Cl_4$, corresponding to the analogous platinum compounds.—On hydrocinnamide, by M. Marcel Delépine. The crystallised hydrocinnamide has the composition $2C_{27}.H_{24}.N_2.H_2O$, and possesses the properties of the glyoxalidines. It is a base forming stable salts, and the name cinnamine is proposed as more suitable than hydrocinnamide.—On an oxyptomaine, by M. Œschner de Coninck. The pyridic ptomaine described in an earlier paper, and which possesses the composition of a collidine, is easily oxidised by hydrogen peroxide to an oxycollidine,

$$C_8H_{10}(OH).N,$$

from which the original base can be regenerated by distillation with zinc-dust.—On the oxidation of sorbite to sorbose, by M. Gabriel Bertrand. An examination of the experiments of M. Matrot upon the same subject, according to which sorbose is produced whatever ferment be employed in the oxidation. This result is controverted in the present paper, the method of oxidation used by M. Matrot, in which the cultures are exposed to contamination by air organisms, being the cause of the effects observed.—On the preparation of white wines from red grapes, by M. V. Martinand. The fermentation is interrupted by cooling, and the colour removed by aëration of the liquid. After filtration from the solid deposit, the fermentation is completed.—On the influences of intermittent rest and work upon the mean power of a muscle, by MM. André Broca and Charles Richet. When the load on the muscle is below a certain limit, intermittent repose is harmful; for moderate loads, without any effect; and with still greater weights, favourable to the production of work.—Evolution and structure of the conjunctive elements in *Paludina*, by M. Joannes Chatin.—The dissociation of the egg in a large number of distinct individuals, and the cycle of evolution in *Encyrtus fuscicollis*, by M. Paul Marchal.—On optical anomalies and polymorphism, by M. Fréd. Wallerant.—Contribution to the geology of Lower Sénégal, by M. Stanislas Meunier.

AMSTERDAM.

Royal Academy of Sciences, January 29.—Prof. van de Sande Bakhuyzen in the chair.—Prof. Jan de Vries, on some groups of circles. Construction of a system of n lines, forming (n_3) triangles, whose circumscribed circles pass through the same point. Inversion of a quadrilateral and its four circles into a spherical configuration of eight points and eight circles. The analogous spherical configuration 16_8 in connection with Miquel's theorem on the pentagon.—Prof. Martin exhibited a new crystalline form of gold, a perfect tetrahedron, found in Brazil. On the ground of the existence of this crystal the speaker considered hemihedrism of gold possible, though not proved by this single specimen.—Prof. Kluyver presented a paper, entitled "On the binominal development," dealing with the Rev. Simmons's New Theorem in Probability (*Proceedings* of the London Mathematical Society, 1895, p. 290). A method of investigation entirely different from that used by the Rev. Simmons enabled the author to confirm the results arrived at by the latter, concerning the "complete sets" of trials. As for the "broken sets," the same method led to a first approximation of the "advantage," from which it was possible to derive the conditions that must be satisfied, if the probability of net gain is to exceed the probability of net loss.—Prof. Jan de Vries presented, on behalf of Dr. G. de Vries, of Haarlem, a paper entitled "Le tourbillon cyclonal." By this the author means a vortex, which is at the same time both a ring vortex and a columnar vortex, in which, consequently, motion takes place along spirals. After deducing the equations of motion in cylindrical coordinates, a general solution is given, through which a differential equation for the current function is arrived at.—Prof. Moll presented, on behalf of Mr. J. H. Bonnerra, of Leeuwarden, a paper entitled "Sedimentary Erratics of Kloosterholt" (Heiligerlee). The erratics treated of in this paper have been gathered from boulder-clay. While the sedimentary erratics from Groningen bear a great resemblance to certain strata in the Russian Baltic provinces, those of Kloosterholt are more like certain Swedish rocks. As regards their geological age, most of them must be classed with the Silurian and the Chalk formation, while Cambrian Jurassic and Tertiary formations are more sparingly represented.

DIARY OF SOCIETIES.

THURSDAY, MARCH 10.

ROYAL SOCIETY, at 4.30.—(1) On the Rotation of Plane of Polarisation of Electric Waves by a Twisted Structure. (2) On the Production of a "Dark Cross" in the Field of Electro-magnetic Radiation: Prof. J. C. Bose.—An Extension of Maxwell's Electro-magnetic Theory of Light to include Dispersion, Metallic Reflection, and Allied Phenomena: E. Edser.—On the Relative Retardation between the Components of a Stream of Light produced by the Passage of the Stream through a Crystalline Plate, cut in any Direction with respect to the Faces of the Crystal: J. Walker.—On the Relation between the Diurnal Range of Magnetic Declination and horizontal Force, and the Period of Solar Spot Frequency: W. Ellis.

ROYAL INSTITUTION, at 3.—Recent Researches on Magnetism and Diamagnetism: Prof. J. A. Fleming, F.R.S.

SOCIETY OF ARTS (Indian Section), at 4 30.—India and Sir Henry Maine: Charles Lewis Tupper, C.S.I.

MATHEMATICAL SOCIETY, at 8.—The Geodesic Geometry of Surfaces in non-Euclidean Space: A. N. Whitehead.—The Transformation of Linear Partial Differential Operators by Extended Linear Continuous Groups: Prof. Elliott, F.R.S.—Stereographic Illustrations of Catenaries: Prof. Greenhill, F.R.S., and T. I. Dewar.—On Linear Homogeneous Continuous Groups whose operations are Permutable: Prof. W. Burnside, F.R.S.—Supplementary Note on Aurifeuillians: Lieut.-Colonel Cunningham, R.E.—On the Calculation of the Sum of the mth Powers of a Large Number of Magnitudes: W. F. Sheppard.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—On the Manufacture of Lamps and other Apparatus for 200 volt Circuits: G. Binswanger-Byng.

FRIDAY, MARCH 11.

ROYAL INSTITUTION, at 9.—Marked Unexplored: W. F. Lord.

ROYAL ASTRONOMICAL SOCIETY, at 8.—On a convenient Method of Adjusting a Polar Axis to the Diurnal Motion: D. P. Todd.—Nebulæ discovered at the Royal Observatory, Cape of Good Hope: Royal Observatory, Cape of Good Hope.—List No. 7 of new Nebulæ: L. Swift.—Long enduring Spots on Jupiter: A. S. Williams.—The Concave Grating for Stellar Photography: C. L. Poor.—On the Fallacy Associated with the Current Rotation Periods of Venus: E. M. Antoniadi.—Equatorial Comparisons of Neptune with 114 Tauri: J. Tebbutt.—A Remarkable Object in Perseus: Rev. T. E. Espin.—On the "Two Method" Personal Equation: W. W. Bryant.—A few Suggestions with Reference to the Newtonian Reflector: T. W. Bush.—The Spectrum of o Ceti, as Photographed at the Stonyhurst College Observatory: Rev. W. Sidgreaves.—The Effect of Latitude Variation on the Ecliptic Investigation: W. G. Thackeray.—Note on Dr Gill's Paper on the Effect of Chromatic Dispersion of the Atmosphere on the Parallaxes of α Centauri and β Orionis: Prof. A. A. Rambaut.

PHYSICAL SOCIETY, at 4.—Council Meeting.—At 5.—On Dynamical Illustrations of certain Optical Phenomena: Prof. J. D. Everett, F.R.S.—On Properties of Liquid Mixtures: R. A. Lehfeldt.

INSTITUTION OF CIVIL ENGINEERS, at 8.—The Drainage of Cottage Property: H. C. Adams.

MALACOLOGICAL SOCIETY, at 8.—The Mollusca of Lake Tanganyika, with especial reference to their Origin and Affinities: J. E. S. Moore.—On the Anatomy of *Mulleria* and *Mutela*: M. F. Woodward.

MONDAY, MARCH 14.

SOCIETY OF ARTS, at 8.—The Thermo-Chemistry of the Bessemer Process: Prof. W. N. Hartley, F.R.S.

ROYAL GEOGRAPHICAL SOCIETY, at 8.30.—Exploration in Spitsbergen, 1897: Sir W. Martin Conway.

SOCIETY OF CHEMICAL INDUSTRY, at 8.—Electrical Industries at the Foyers Waterfalls: R. W. Wallace.

TUESDAY, MARCH 15.

ROYAL INSTITUTION, at 3.—The Simplest Living Things: Prof. E. Ray Lankester, F.R.S.

SOCIETY OF ARTS (Foreign and Colonial Section), at 4 30.—The West Indies and Sugar Bounties: Nevile Lubbock.

ZOOLOGICAL SOCIETY, at 8.30.—On New or Imperfectly Known Species of Ostracoda, chiefly from New Zealand: Dr. G. Stewardson Brady, F.R.S.—On a New Flagellate Protozoan of the Genus *Lophomonas*: E. H. J. Schuster.—On the Early Post-Larval Stages of the Crab (*Cancer pagurus*), and on the Affinity of that Species with *Atelecyclus heterodon*: J. T. Cunningham.

INSTITUTION OF CIVIL ENGINEERS, at 8.—Calcium Carbide and Acetylene: Henry Fowler.

ROYAL PHOTOGRAPHIC SOCIETY, at 8.—Half-tone Negative-making: W. H. Lascelles.

ROYAL VICTORIA HALL, at 8.30.—Wireless Telegraphy: A. W. Porter.

ROYAL STATISTICAL SOCIETY, at 5.

WEDNESDAY, MARCH 16.

SOCIETY OF ARTS, at 8.—The Recent History of Paper-making: Clayton Beadle.

ROYAL GEOGRAPHICAL SOCIETY, at 4.30.—Sea Beaches and Sand Banks: Vaughan Cornish.

ENTOMOLOGICAL SOCIETY, at 8.—Further Notes on Dyscritina, Westw.: E. E. Green.

ROYAL METEOROLOGICAL SOCIETY, at 7.30.—Photographing Meteorological Phenomena: Arthur W. Clayden.

ROYAL MICROSCOPICAL SOCIETY, at 8.—Exhibition of Mounted Rotifers: G. F. Rousselet.

THURSDAY, MARCH 17.

ROYAL SOCIETY, at 4.30.—The Croonian Lecture will be delivered by Prof. Wilhelm Pfeffer, For. Mem. R.S. On the Nature and Significance of Functional Metabolism (Betriebs-stoffwechsels) in the Plant.

ROYAL INSTITUTION, at 3.—Magnetism and Diamagnetism: Prof. J. A. Fleming, F.R.S.

LINNEAN SOCIETY, at 8.—Natural Selection the Cause of Mimetic Resemblance and Common Warning Colours: Prof. E. B. Poulton, F.R.S.—On the Brain of the Edentata, including Chlamydophorus: Dr. Elliott Smith.—On Limnocarpus, a New Genus of Fossil Plants from the Tertiary Deposits of Hampshire: Clement Reid.

CHEMICAL SOCIETY, at 8.—The Reduction of Bromic Acid and the Law of Mass Action: Winifred Judson and Dr. J. Wallace Walker.—The Action of Ferric Chloride on the Ethereal Salts of Ketone Acids:—Dr. R. S. Morell and Dr. J. M. Crofts.—Note on the Volatility of Sulphur: T. C. Porter.—Action of Ammonia and Substituted Ammonias on Acetylurethane: Dr. George Young and Ernest Clark.—Cannabinol: T. B. Wood, W. T. N. Spivey, and Dr T. H. Easterfield.—Formation of Oxytriazoles from Semicarbazides: Dr. G. Young, and B. M. Stockwell.

INSTITUTION OF CIVIL ENGINEERS, at 8.—Sixth "James Forrest" Lecture, Geology in Relation to Engineering: Prof. W. Boyd Dawkins, F.R.S.

CAMERA CLUB, at 8.15.—Some Recent Animal Photographs: Gambier Bolton.

FRIDAY, MARCH 18.

ROYAL INSTITUTION, at 9.—The Bringing of Water to Birmingham fro the Welsh Mountains: J. Mansergh.

BOOKS, PAMPHLET, and SERIALS RECEIVED.

BOOKS.—Peregrinazioni Antropologische e Fisiche, &c.: Dr. T. Vignoli and Prof. G. V. Schiaparelli (Milano, Hoepli).—Travels in the Coastlands of British East Africa &c.: W. W. A. Fitzgerald (Chapman).—L'Algérie: J. A. Battandier and L. Trabut (Paris, Baillière).—Epidemic Diphtheria: Dr. A. Newsholme (Sonnenschein).—Magnetical and Meteorological Observations made at the Government Observatory, Bombay, 1896 (Bombay).—Geological Literature added to the Geological Society's Library during the Year ended December 31, 1897 (Geological Society).—Royal Geographical Society. Year-Book and Record, 1898 (Royal Geographical Society).—La Photographie et l'Étude des Nuages: J. Boyer (Paris, C. Mendel).—The Teacher's Manual of Object-Lessons in Domestic Economy, V. T. Murché: Vol. 1 (Macmillan).—General Elementary Science (Clive).

PAMPHLET.—Review of Mineral Production in India for 1896 (Calcutta).

SERIALS.—Bulletin de l'Académie Royale des Sciences, &c., de Belgique, 1898, No. 1 (Bruxelles).—Journal of the Royal Microscopical Society, February (Williams).—Zeitschrift für Physikalische Chemie, xxv. Band, 2 Heft (Leipzig, Engelmann).—Middlesex Hospital Journal, Vol. 2, No. 6 (London).—Quarterly Journal of the Geological Society. February (Longmans).—Journal of Botany, March (West).—Scribner's Magazine, March (Low).—Archives de Parasitologie, January (Paris, Carré).—Revue de l'Université de Bruxelles, March (Bruxelles).—National Review, March (Arnold).—Fortnightly Review, March (Chapman).—National Geographic Magazine, February (Washington).—Transactions of the American Microscopical Society, December (Buffalo).—Geographical Journal, March (Stanford).—Astrophysical Journal, February (Chicago).—Atlantic Monthly, March (Gay).

CONTENTS.

	PAGE
Two Text-Books of Elementary Geometry. By G. B. M.	433
Our Book Shelf:—	
Bjorling: "Whittaker's Mechanical Engineer's Pocket-Book."—**H. B.**	434
Wyatt: "Handbooks of Practical Science"	435
Kerr: "Science Handbooks for Laboratory and Class Room"	435
Mitchell: "Quantitative Practical Chemistry"	435
Ransome: "Researches on Tuberculosis. The Weber-Parkes Prize Essay, 1897."—**F. W. T.**	435
"The *Electrician* Electrical Trades' Directory and Handbook for 1898"	435
"The Universal Electrical Directory (J. A. Berly's)"	435
Rowan: "A Flower Hunter in Queensland and New Zealand"	436
Tappeiner: "Introduction to Chemical Methods of Clinical Diagnosis."—**F. W. T.**	436
Letters to the Editor:—	
Five-fingered Crab. (*Illustrated.*)—**R. I. Pocock**	436
Dew and Absorption.—**T. Wilson**	436
Oat Smut as an Artist's Pigment.—**Kumagusu Minakata**	437
Geological Photographs. (*Illustrated.*) By **Prof. W. Watts**	437
Some Rare Birds' Eggs. By **R. L.**	438
Notes	440
Our Astronomical Column:—	
Occultation of Antares	442
Nautical Almanac, 1901	442
Variable Star U Pegasi	442
The Photography of Nebulæ. (*Illustrated.*) By **Prof. R. A. Gregory**	443
Photo-micrography with High Powers. (*Illustrated.*) By **J. Edwin Barnard** and **Thomas A. B. Carver**	448
A Method of Measuring Wind Pressure	449
An Enchanted Mesa. (*Illustrated.*)	450
University and Educational Intelligence	451
Societies and Academies	452
Diary of Societies	456
Books, Pamphlet, and Serials Received	456

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